ASSESSMENT OF DEGREE OF TREATMENT DIFFICULTY OF MAXILLARY CANINE IMPACTION USING KPG INDEX AND TO ANALYSE LATERAL INCISOR ROOT RESORPTION BY 3D CBCT- A RETROSPECTIVE STUDY.

Dissertation Submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

For partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

BRANCH – V

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

THE TAMILNADU DR. M.G.R MEDICAL UNIVERSITY

CHENNAI – 600 032

2012 – 2015

CERTIFICATE

This is to certify that **Dr. C.ROOPA @ KUNTHAVAI**, Post graduate student **(2012 – 2015)** in the Department of Orthodontics and Dentofacial orthopaedics branch V, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003 has done this dissertation titled ***"Assessment of degree of treatment difficulty of maxillary canine impaction using KPG index and to analyse lateral incisor root resorption by 3D CBCT- A retrospective study"*** under my direct guidance and supervision for partial fulfillment of the M.D.S degree examination in April 2015 as per the regulations laid down by The Tamil Nadu Dr. M.G.R. Medical University, Chennai -600 032 for **M.D.S., Orthodontics and Dentofacial orthopaedics (Branch – V)** degree examination.

Guided By

Dr. B.BALASHANMUGAM M.D.S.,

Professor ,

Department of Orthodontics & Dentofacial Orthopaedics,

Tamil Nadu Government Dental College & Hospital,

Chennai - 600 003

Dr. SRIDHAR PREMKUMAR M.D.S.,

Principal,

Tamil Nadu Government Dental College, & Hospital,

Chennai - 600 003

DECLARATION

I, **Dr. C. ROOPA @ KUNTHAVAI**, do hereby declare that the dissertation titled ***"Assessment of degree of treatment difficulty of maxillary canine impaction using KPG index and to analyse lateral incisor root resorption by 3D CBCT- A retrospective study"*** was done in the Department of Orthodontics, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government Dental College for the study in partial fulfillment of the requirements for the degree of Master of Dental Surgery in the speciality of Orthodontics and Dentofacial Orthopaedics (Branch V) during the course period **2012-2015** under the conceptualization and guidance of my dissertation guide, **Professor Dr. B. BALASHANMUGAM MDS.**

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from The Tamil Nadu Government Dental College & Hospital.

I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

Signature of the PG student **Signature of the HOD**

Signature of the Head of the Institution

ACKNOWLEDGEMENT

My sincere and heartfelt thanks to **Dr. SRIDHAR PREMKUMAR, M.D.S.,** our Principal and Professor of Orthodontics, Tamil Nadu Government Dental College and Hospital, Chennai – 3,for his continuous and enormous support in allowing me to conduct this study and for his constant encouragement and advice during my tough phases in curriculum.

With my heartfelt respect, immeasurable gratitude and honour, I thank my benevolent guide, **Dr. B. BALASHANMUGAM M.D.S.,** Professor, Department of Orthodontics and Dentofacial orthopedics, Tamil Nadu Government Dental College and Hospital, Chennai – 3, for his astute guidance, support and encouragement throughout my post graduate course and to bring this dissertation to a successful completion.

I owe my thanks and great honour to **Dr. G. VIMALA M.D.S.,** Professor & HOD, Department of Orthodontics and Dentofacial Orthopaedics, Tamilnadu Govt. Dental College and Hospital, Chennai - 3, for helping me with her valuable and timely suggestions and encouragement.

I sincerely thank Associate professors **Dr. G. Usha Rao, Dr. M. Vijjaykanth, Dr. M. D. Sofitha** and Senior Assistant professors **Dr. K. Usha, Dr. D. Nagarajan, Dr. Mohammed Iqbal, Dr. M.S. Jayanthi** and Assistant professor **Dr. R. Selvarani** for their continuous support and encouragement.

I extend my sincere thanks to **Dr. S .JAYACHANDRAN, M.D.S., Ph.D,** Professor and HOD, Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College & Hospital, who provided me the CBCT records available in the department and helped in completing this study successfully.

I thank **Dr. R. Saravanan** and **Dr. Neeru chahal** for helping me in reliability assessment in this study.

I thank **Mr. Boopathy** for helping me in statistical analysis.

I also thank my post graduate colleagues for their help and constant support.

I thank **my family** for their unconditional love and affection and constant support. Without them, nothing would have been made possible.

Lastly, I wholeheartedly thank my sister **Mrs. C. Geetha Andal (late**) who has showered her blessings from above and who is behind each and every step in my life.

TRIPARTITE AGREEMENT

This agreement herein after the "Agreement" is entered into on this..... day of December 2014 between the Tamil Nadu Government Dental College and Hospital represented by its **Principal** having address at Tamilnadu Government Dental college and Hospital, Chennai-03, (hereafter referred to as , 'the college')

And

Dr. B. BALASHANMUGAM aged 43years working as professor at the college, having residence address at 8-B,Crescent road, Shenoy nagar,Chennai-600030, Tamilnadu (Herein after referred to as the 'Principal investigator')

And

Dr. C. ROOPA @ KUNTHAVAI aged 33 years currently studying as postgraduate student in department of Orthodontics in Tamilnadu Government Dental College and Hospital (Herein after referred to as the 'PG/Research student and co- investigator').

Whereas the 'PG/Research student as part of his curriculum undertakes to research **"Assessment of degree of treatment difficulty of maxillary canine impaction using KPG index and to analyse lateral incisor root resorption by 3D CBCT- A retrospective study"** for which purpose the PG/Principal investigator shall act as principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator.

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard.

Now this agreement witnesseth as follows:

1. The parties agree that all the Research material and ownership therein shall become the vested right of the college, including in particular all the copyright in the literature including the study, research and all other related papers.
2. To the extent that the college has legal right to do go, shall grant to license or assign the copyright do vested with it for medical and/or commercial usage of interested persons/entities subject to a reasonable terms/conditions including royalty as deemed by the college.
3. The royalty so received by the college shall be shared equally by all the parties.
4. The PG/Research student and PG/Principal Investigator shall under no circumstances deal with the copyright, Confidential information and know – how generated during the course of research/study in any manner whatsoever, while shall sole vest with the manner whatsoever and for any purpose without the express written consent of the college.
5. All expenses pertaining to the research shall be decided upon by the principal investigator/Co-investigator or borne sole by the PG/research student (co-investigator).
6. The college shall provide all infrastructure and access facilities within and in other institutes to the extent possible. This includes patient interactions, introductory letters, recommendation letters and such other acts required in this regard.
7. The principal investigator shall suitably guide the student Research right from selection of the Research Topic and Area till its completion. However the selection and conduct of research, topic and area research by the student researcher under guidance from the principal investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the college constituted for this purpose.
8. It is agreed that as regards other aspects not covered under this agreement, but which pertain to the research undertaken by the student Researcher, under guidance from the Principal Investigator, the decision of the college shall be binding and final.

9. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

In witness whereof the parties hereinabove mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its

Principal **PG Student**

Witnesses **Student Guide**

1.
2.

CONTENTS

LIST OF TABLES

LIST OF COLOUR PLATES

ABBREVIATIONS

CT	-	Computed Tomography
CBCT	-	Cone Beam Computed Tomography
DPT	-	Dental pantomograph
et al	-	And Others
EXT	-	Extremely
F	-	Female
FOV	-	Field of View
H × W	-	Height by Width
IMC	-	Impacted maxillary canine
KV	-	Kilovoltage
KPG	-	Kau, Pan Philip, Galleranno
LIRR	-	Lateral Incisor Root Resorption
LP	-	Labiopalatal
LAT	-	Lateral
M	-	Male
MBI	-	Mesio Buccal Impaction
Mid alv	-	Midalveolus
MPI	-	Mesio Palatal Imapction
mSv	-	Millisieverts
MA	-	Milliampere
µSv	-	Microsieverts
N	-	Number
NRCP	-	National Council on Radiation Protection and Measurements
OPG	-	Orthopantamogram
ROI	-	Region of Interest
SPSS	-	Statistical Package for Social Sciences
2-D	-	2-Dimensional
3-D	-	3- Dimensional

INTRODUCTION

Impaction is a condition which is defined as "lack of eruption of a tooth in the oral cavity within the time and physiological limits of normal eruption process"[1] Most commonly encountered impacted teeth are third molars, followed by maxillary canine and mandibular second premolar[2]. Disturbances in the eruption of maxillary permanent canines are common because they have the longest period of development, the most superior area of development and the most difficult path of eruption compared with any other tooth in the oral cavity[3,4]. Impacted canines may result in several complications such as displacement and root resorption of adjacent teeth, cystic degeneration, canine ankylosis, shortening of the dental arch or combinations of these factors[5]. Canines play an important functional and aesthetical role in face.

Maxillary canine impaction is complex in its etiology, localization, response to preventive treatments, and prediction. It is a dilemma for many orthodontists in determining whether canine impaction will occur and timing the treatment modalities for a successful outcome. If, in these cases, orthodontic treatment is not initiated at an early age, ankylosis of the canine and detrimental effects on incisor roots are possibilities[6].Moreover orthodontics have emphasized the importance of preserving impacted maxillary canines and introduced various effective techniques for the treatment of this condition[4]. Therefore, it is imperative to locate and categorize impacted canines accurately for their optimal

management[7]. Early detection of impacted maxillary canines could reduce the time, complexity, and cost of the treatment as well as its complications[8]. Management of an impacted tooth usually requires interventions of an orthodontist and oral and maxillofacial surgeon. The interventions could be very different including removing the impacted tooth and replacing it with a premolar or prosthetic restoration, removing lateral tooth and replacing it with the impacted canine, removing premolar teeth and bringing the impacted canine inside the arch, or even doing no intervention. Some parameters such as location of the impacted tooth, prognosis of the interventions on the impacted tooth and the adjacent teeth, surgical accessibility, and final treatment functionality have influences on the selection of the intervention. Hence Management of impacted teeth requires accurate and precise diagnosis regarding location of an impacted tooth and its relationship with the surrounding anatomical structures. It is important to determine and evaluate the exact position of an impacted tooth, inclination of long axis of an impacted tooth and its relationship to the neighbouring structures such as adjacent teeth, to enact a treatment plan after diagnosis.

The radiographic and imaging examination is certainly an indispensible tool for precise diagnosis and optimal management without any further complication because it provides valuable information about tooth position, number and morphology of roots, and relationship of tooth to adjacent anatomical structures. Always the first choice of imaging modality should be the plain or conventional radiography when an

impacted tooth is suspected after clinical examination. For preoperative diagnosis of routine cases, intraoral and panoramic radiographs are sufficient to determine the position of the impacted canine in two dimensional. But additional information from other imaging modalities is needed in the second plane to analyse in three dimensional that axial, coronal and sagittal views. Moreover conventional radiographs have their inbuilt drawbacks like superimposition, distortion of images, because of the projection of 3dimensional structures in 2 dimension hence the advanced imaging is necessary for the assessment of impacted canines. CT has been used for past several years because it can provide additional and reliable information than conventional radiographs. CT provides good tissue contrast, eliminates blurring of image and overlapping of adjacent anatomical structures. Despite its advantages, until now, the use of CT for the assessment of impacted teeth has been restricted because of issues related to cost, risk versus benefit, and access[9].

CBCT (cone beam computed tomography) is a recent technology initially developed for angiography in 1982 and subsequently applied to maxillofacial imaging[10].CBCT uses a cone shaped X-ray beam, resulting in a 3D reconstruction of the teeth and jaws. With the availability of the cone beam computed tomography (CBCT), it is possible to precisely position the impacted canines, determine the amount of bone covering it and evaluate the condition of adjacent anatomic structures.[11]

Currently, many attempts through various studies have been made to investigate the role of CBCT in the imaging of impacted teeth. CBCT provides high definition three dimensional images of oral and maxillofacial structures at reduced cost and lesser radiation dose to the patient. It has also overcome the limitations of conventional imaging such as distortion of image, magnification of image, less clarity, overlapping of anatomical structures, lack of accuracy in measurements and not allowing for 3dimensional modelling. Further additional information such as three dimensional orientation of an impacted tooth, and direction of path of eruption is best revealed with CBCT. CBCT can identify and locate the position of impacted canines accurately and can also assess damage to the roots of adjacent teeth and amount of bone surrounding each tooth [4,12] .Simple 2D classifications of canine impactions have been developed. These often require a second radiograph to be taken.

The KPG index is the first 3-D classification system for classifying the position of canines based on their distance from the norm. This index for the classification of canine impactions has been developed in an effort to standardize diagnosis and predict treatment difficulty. This KPG(Kau, PhilipPan, Gallerano) index represents the first index that uses the 3D of space in a 3D volume for understanding of spatial relationship of the impacted tooth. Understanding the precise location and variation of orientation of the impacted canines can be of benefit to oral surgeons and orthodontists in their treatment planning.[13]

The present study was aimed to assess the degree of difficulty for the treatment of impacted maxillary canines using KPG index and to analyse the lateral incisor root resorption using CBCT. This is to add increased validation to this index and to compare with the 2D measurements.

.

AIMS AND OBJECTIVES

AIM

The aim of the study is to assess the degree of difficulty for the treatment of impacted canines using KPG index and to analyse the lateral incisor root resorption using CBCT.

OBJECTIVES

- To determine the position of maxillary canine in 3D and analyse type of impaction.
- To assess the degree of difficulty for the treatment of impacted maxillary canine using KPG index.
- To find the reliability in assessing the KPG index by inter and intrarater agreement.
- To find the agreement between 2D and 3D methods in predicting treatment difficulty.
- To relate the severity of Lateral incisor root resorption to score of KPG index.

REVIEW OF LITERATURE

PREVALENCE,ETIOLOGY AND SEQUELAE OF CANINE IMPACTION

Thilander and Jakobsson[14]in the year **1968**said a tooth is considered impacted when there is a delay in its eruption and there is clinical or radiographic evidence showing that future eruption may not take place**.**

Ericson and Kurol in 1986[15]estimated the incidence at 1.7%. Impactions are twice as common in females (1.17%) as in males (0.51%). Of all patients with maxillary impacted canines, it is estimated that 8% have bilateral impactions. The incidence of mandibular canine impaction is 0.35%.

Jacoby H in1983[16] states the etiology of tooth impactions has long been related to an arch-length deficiency. This is valid for most impactions, but not for palatal impaction of the maxillary canine. An arch-length deficiency will not allow the maxillary canine to "jump" the buds, the nasal cavity, or the sinus in order to reappear in the palate. A dysplasia in the maxillary-premaxillary suture can also modify the direction of the maxillary canine's eruption. He reports the number of palatally impacted maxillary canines slightly higher in his studies, ranging between 87-92%.

Jacobs SG in 1996[17]stated that the aetiology of palatally displaced canines is genetic in origin. The aetiology of labially impacted canines differs, being due to inadequate arch space. Suspicions that an impaction could occur or has occurred arise a) before the age of 10 years if there is a familial history and or the maxillary

lateral incisors are anomalous or missing b) after the age of 10 years if there is asymmetry in palpation or a pronounced difference in eruption of canines between the left and right side or the canines cannot be palpated and occlusal development is advanced or, the lateral incisor is proclined and tipped distally and, on a panoramic radiograph of the late mixed dentition if the incisal cusp of the canine overlaps the root of the lateral incisor.

Becker A et al in 1999[18] did a randomized controlled research and studied cases affected by a severe expression of lateral incisor anomaly on one side and by a milder expression of the same anomaly on the other, comparison of frequency of occurrence of unilateral palatally displaced canine measured in each side acted as control for the other within the same individual. Missing lateral incisors, peg-shaped, and reduced lateral incisors (all genetically determined characters) have been shown to be associated with palatal displacement of the canine.

Becker A et al in2000[19] reported an etiologic connection between palatally ectopic canines. Additionally, it has been observed that patients with palatally ectopic canines have a delayed dental development. They radiographically assessed the subjects' dental ages using criteria of tooth calcification, rather than tooth eruption pattern. The results support the idea that there are different aetiologies for the occurrence of buccal versus palatal ectopic maxillary canines. They also suggest that dentitions with a palatal canine appear to be of 2 distinct varieties, with different dental characteristics and, perhaps, different aetiologies.

Suri L et al in 2004[20] reviewed the local and systemic conditions under which delayed tooth eruption (DTE) deviates significantly from norms established for different races, ethnicities, and sexes . The terminology related to disturbances in tooth eruption is also reviewed and clarified. A diagnostic algorithm was proposed to aid the clinician in the diagnosis and treatment planning of DTE. The sequential and timely eruption of teeth is critical to the timing of treatment and the selection of an orthodontic treatment modality

Sacerdoti R et al in the year 2004[21] conducted a study to analyze the prevalence and distribution of palatally displaced maxillary canines (PDC) and to investigate the associations between PDC, craniofacial features, and other dental anomalies such as aplasia or small-sized upper lateral incisors. Unilateral PDC was significantly associated with aplasia of upper lateral incisors, whereas bilateral PDC was associated with aplasia of third molars. PDC showed reciprocal significant associations with bilateral small-sized upper lateral incisors. None of the three hypotheses offered in support of the "guidance theory" in the aetiology of PDC were corroborated by the findings of the present study.

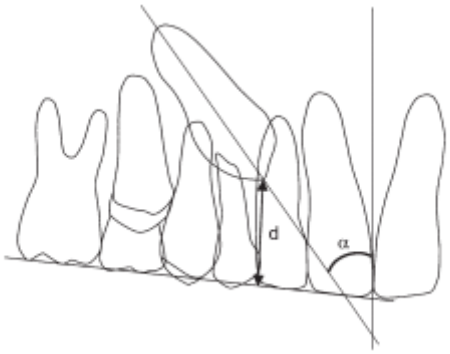
George Listasa et al in 2011[22] reviewed theories related with the etiology of impacted canines and predictive variables of canine impaction in the mixed dentition. The impaction of the maxillary permanent canine is a common finding of oral pathology and represents 2% of patients seeking orthodontic treatment. Maxillary canine is one of the most frequently impacted teeth, second only to third molars with the prevalence ranging from 0.8 to 5.2 percent depending on the population examined. The incidence of canine impaction in the maxilla is more

than twice than that in the mandible, and the ratio of palatal to buccal impaction is 8 to 1. Eight percent of canine impactions are bilateral and it is twice more common in girls than boys. Primary etiological causes of maxillary canine displacement include space deficiency, disturbances in tooth eruption sequence, trauma, retention of primary canine, premature root closure, rotation of tooth buds, as well as localized pathological lesions (cysts, odontomas).There are two other theories that have been widely supported to explain the occurrence of palatally impacted maxillary canines: guidance theory and genetic theory. Guidance theory proposes that the canine lacks guidance during eruption due to a hypoplastic or missing permanent lateral incisor This theory is supported by studies that show palatal impactions are frequently found in dentitions with missing or peg-shaped lateral incisors. Genetic theory explains that maxillary canine impaction occurs because of a developmental disturbance of the dental lamina. This theory cites evidence such as associations with hypodontia, female predilection, and increased familial and bilateral occurrence as support.

FOR 2D ASSESSMENT OF CANINE IMPACTION

Ericson and Kurol in1987[23,24] developed a method for predicting palatally erupting maxillary canines after deciduous canine extraction. The position of canine was determined in 3planes,in frontal view(OPG), in the transverse plane(vertex projection),in the sagittal plane(lateral head film)

1.The mesial inclination of the crown of the canine to the midline (α angle)

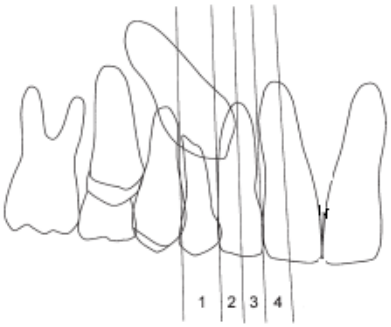


2. The distance of the cusp tip of the permanent canine from the occlusal line (d).
3. The medial crown position in sectors (1 – 5)

Lindauer and colleagues(1992)[25]drawing on the work of Ericson and Kurol(1987) developed a method based on the location of the impacted canine cusp tip and its relationship to the adjacent lateral incisor. Dividing impacted canines into four groups—sectors I through IV, with sector IV representing the most severe impaction—they determined that as many as 78% of the canines with cusp tips in sectors II through IV were destined to become impacted.

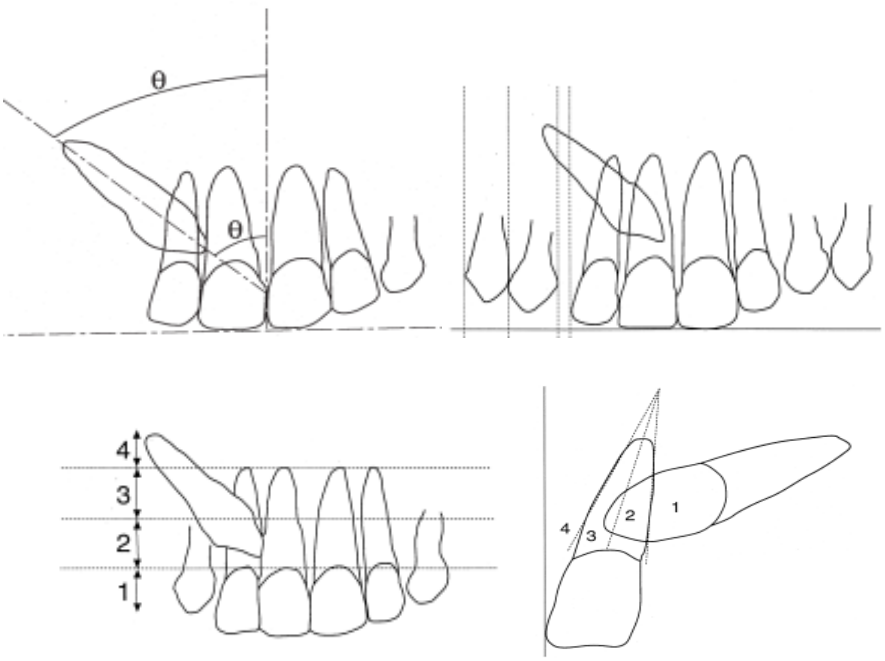
- Sector I—cusp tip distal to a line tangent to the distal heights of contour of the lateral incisor crown and root.
- Sector II—mesial to sector I, with the cusp tip distal to a line bisecting the mesiodistal dimension of the lateral incisor along the long axis.
- Sector III—mesial to sector II, with the cusp tip distal to a line tangent to the mesial heights of contour of the lateral incisor crown and root.

- Sector IV—any position mesial to sector III.



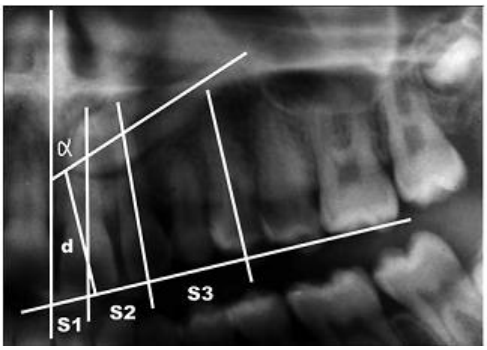
Power and Short in1993 [26] found that if a canine is angled more than 31°to the midline, its chance of eruption after deciduous extraction is reduced. The effect of the removal of deciduous canines on palatally displaced maxillary canines was assessed and factors contributing to a successful outcome were analysed. They used a orthopantomogram for assessment. The cases were examined clinically and radiographically for a maximum period of 2 years following deciduous canine removal. Twenty-nine (62 per cent) of the 47 ectopic canines achieved a normal eruptive position and nine (19 per cent) showed some improvement in eruptive position. The outcome of the removal of the deciduous canine depended on the position of the permanent canine. Horizontal overlap of the nearest incisor was found to be the most significant factor. If this exceeded half the tooth width, success was unlikely.

Stivaros et al [27]in the year **2000** evaluated the importance of radiographic factors such as canine angulation, height, and bucco-palatal position from lateral skull and OPG radiographs which has not been investigated in the previous studies. The orthodontists' decision to expose or remove an impacted upper permanent canine, based on radiographic information, seems to be primarily guided by its labiopalatal position and it angulation to the midline.



Cresini et al in 2007[28]evaluated the position of the impacted canine on the panoramic radiograph by using a modified version of the criteria proposed by Ericson and Kurol(1987):

- α -angle: Angle measured between the long axis of the impacted canine and the midline.
- d-distance: Distance between the canine cusp tip and the occlusal plane (from the first molar to the incisal edge of the central incisor).
- s-sector: Sector where the cusp of the impacted canine is located: sector 1, between the midline and the axis of the central incisor; sector 2, between the axis of the central incisor and the axis of the lateral incisor; or sector 3, between the axis of the lateral incisor and the axis of the first premolar.



Every 5˚of opening of the angle required approximately 1 more week of active orthodontic traction. Every 1 mm of distance of the cusp of the impacted canine from the occlusal plane required approximately 1 more week of active orthodontic traction. Impaction in sector 1 required approximately 6 more weeks of active orthodontic traction when compared to impaction in sector 3.

Steward et al in the year 2001[29]**s**tudied the relationship between the antero posterior position, vertical position and angulation of a palatally impacted maxillary canine to the duration of orthodontic treatment. It concluded that the greater the distance the impacted canine was from the occlusal plane, the greater the angulation and more medially displaced it was. When the impacted canine crown was at a distance from the occlusal plane of less than 14 mm, treatment time averaged 23.8 months; a distance of more than 14 mm required an average treatment time of 31.1 months.

Warford et al in 2003[30] measured the angulation of the unerupted tooth from panoramic radiographs and added to sector locationto see whether the combination of these factors could predict impaction more accurately than sector alone. Sector was found to be the better predictor of impaction, with angulation adding little supplementary predictive value.

Sarah Pitt et al in 2006 [31]produced a treatment difficulty index (TDI) that could be used to measure the difficulty expected during the alignment of unerupted maxillary canines by examining 10 factors including age of the patient, alignment of incisors, space between lateral incisor and first premolar.TDI was calculated using the regression equation showed good correlation with the initial clinical judgements.

FOR 3D ASSESSMENT OF CANINE IMPACTION

Computerized tomography (CT) For the past few years, CT has become the imaging modality of choice as they provide more realistic information than conventional radiographic imaging techniques. CT scan provides accurate position, orientation, and inclination of an impacted tooth, its relationship with adjacent neighbouring anatomical structures in all the three dimensions. With CT, it has become possible to localize impacted teeth accurately and precisely assess the relationship of impacted teeth with adjacent vital anatomic structures, assess the presence of root resorption in the adjacent teeth and also detects the associated pathology if present. However due to high cost and especially high radiation doses[32], routine use of CT for diagnosis of an impacted tooth is not justified.

Craniofacial CBCTs were designed to counteract some of the limitations of the conventional CT scanning devices.[33] The object to be evaluated is captured as the radiation source falls onto a two-dimensional detector. This simple difference allows a single rotation of the radiation source to capture an entire region of interest, as compared to conventional CT devices where multiple slices are stacked to obtain a complete image.[34] The cone beam also produces a more

focused beam of x-ray and significantly less scatter radiation compared to the conventional fan-shaped CT devices, and this considerably increases the X-ray utilization and reduces the ability of X-ray tube required for volumetric scanning.[34,35] It has been reported that the total radiation dose is approximately 20% of conventional CTs and equivalent to a full mouth periapical radiographic exposure.[36] These component innovations are significant and allow the CBCT to be less expensive and smaller. Furthermore, the exposure chamber (i.e. head), is custom built and reduces the amount of radiation. The images are comparable to the conventional CTs and also may be displayed as a full head view, as a skull view or regional components depending upon the field of view.

CONE BEAM COMPUTED TOMOGRAPHY (CBCT)

It is a recent innovation in the field of technology that has achieved rapid acceptance in general, particularly in dentistry despite its current relatively high price when compared with alternative imaging methodologies.

The **first commercial CBCT system** for oral and maxillofacial imaging was the NewTom (Quantitative Radiology, Verona, Italy), which was first approved by the Food and Drug Administration (FDA) in **April 2001**, and is currently in its fourth generation as the NewTom VG. Since that time numerous additional systems have been approved or are in development.[34]

Preda L et al[37] in the year 1997 conducted a study to compare spiral CT with conventional radiography in planning the orthodontic treatment of impacted permanent maxillary canines. Conventional radiography failed to depict root

resorption especially on the buccal surfaces of the incisor teeth. CT located impacted teeth better. CT facilitates the treatment of impacted canine especially when the teeth are very oblique to the arch. Root resorption is better demonstrated especially on the palatal and buccal surfaces of the adjacent incisors.

FreisfeldM et al[38] in the year 1999 conducted a study of X-ray diagnosis of impacted upper canines in panoramic radiographs and computed tomographs. Ten orthodontists were asked to diagnose the number of impacted upper canines and the number of resorbed lateral and/or central incisor roots in 30 panoramic radiographs from 30 patients. The results showed that, due to their low reliability, panoramic radiographs are not an appropriate means of diagnosing resorptions in front teeth in connection with impacted canines.

Walker L et al[9]in the year 2005 conducted a study to describe the spatial relationship of impacted canines by using images 3-dimensional (3D) volumetric imaging obtained with the NewTom QR-DVT 9000. The factors analyzed were proximity to adjacent structures ,resorption of incisors, alveolar width, and follicle size.This study showed that palatal maxillary impactions (92.6%) are more common than buccal impactions (7.4%); this agrees with previous reports. Their findings demonstrate that the 3D volumetric imaging provides invaluable information about impacted canines to better understand and treat these cases surgically and orthodontically.

Alqerban A et al[39] in the year 2011 conducted a study comparing two cone beam computed tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. The clinical records of 60 consecutive patients who had impacted or ectopically erupting maxillary canines were identified from those seeking orthodontic treatment. The results of this study suggest that CBCT is more sensitive than conventional radiography for both canine localization and identification of root resorption of adjacent teeth. This study concludes that use of CBCTs rather than DPT imaging for the assessment of impacted canines has a potential diagnostic effect and may influence the outcome of treatment. Such a technique of free overlap may increase the interpretation of treatment outcome and treatment progress. CBCT may be a reliable method for detecting canine impaction and root resorption of adjacent teeth. A CBCT image establishes the link between 2D and 3D imaging and is more accurate for the different diagnostic tasks in canine impaction than panoramic radiography. Using CBCT with the maximum data available would help reduce unnecessary radiation exposure.

Botticelli S et al[40]in the year 2011 conducted a study to evaluate whether there is any difference in the diagnostic information provided by conventional two-dimensional (2D) images or by three-dimensional (3D) cone beam computed tomography (CBCT) in subjects with unerupted maxillary canines. Twenty-seven patients undergoing orthodontic treatment with 39 impacted or retained maxillary canines were included. The findings demonstrated a difference in the localization of the impacted canines between the two techniques, which can be explained by factors affecting the conventional 2D radiographs such as distortion,

magnification, and superimposition of anatomical structures situated in different planes of space. The increased precision in the localization of the canines and the improved estimation of the space conditions in the arch obtained with CBCT resulted in a difference in diagnosis and treatment planning towards a more clinically orientated approach.

Haney E et al[41]in the year 2012 conducted a prospective study and compared differences in the diagnosis and treatment planning of impacted maxillary canines between 2 imaging modalities. Twenty-five consecutive impacted maxillary canines were identified from the pool of patients seeking orthodontic treatment. The first set of radiographs consisted of traditional 2- dimensional (2D) images including panoramic, occlusal, and 2 periapical radiographs. The second set comprised prints of 3-dimensional (3D) volumetric dentition images obtained from a cone-beam computed tomography (CBCT) scan. The clinicians' confidence of the accuracy of diagnosis and treatment plan was statistically higher for CBCT images ($P < 0.001$). These results showed that 2D and 3D images of impacted maxillary canines can produce different diagnoses and treatment plans.

OberoiS et al[42]in the year 2012 conducted a study to localize impacted canines in 3 dimensions and determine the most common location of impaction using cone beam computed tomography (CBCT). They also assessed root resorption of adjacent teeth. The cusp tip of each impacted canine was located and digitized using Dolphin 3D imaging, after viewing sagittal, coronal, and axial views. The position on the occlusal plane where the normally erupted canine cusp tip should be located was used as a control reference point. The degree of impaction was

defined by the difference between the impacted canine cusp tip and reference cusp tip positions. They assessed the position of impacted canines in 3 dimensions using CBCT, thereby improving accuracy of location and facilitating precise surgical and orthodontic management. The most frequent location of impacted canines was palatal, mesial, and gingival.

WriedtS et al[43]in the year 2012 conducted a study to evaluate whether three-dimensional (3D) diagnostics (cone-beam computed tomography, CBCT) was superior to two-dimensional (2D) diagnostics (panoramic X-ray, OPG) in patients with impacted upper canines for assessing their position and the probability of their alignment. In 64% of all patients, canine position was assessed concordantly in 2D and 3D images. Canine inclination visible in the panoramic X-rays was the most important factor influencing the treatment proposal. Small volume CBCT may be justified as a supplement to a routine panoramic Xray in the following cases: when canine inclination in the panoramic X-ray exceeds 30°, when root resorption of adjacent teeth is suspected, and/or when the canine apex is not clearly discernible in the panoramic X-ray, implying dilaceration of the canine root.

THE KPG INDEX(Kau,PanPhilip,Gallerano)

C.H.Kau et al in 2009[13] assessed the degree of difficulty for the treatment of impacted canines, based on the 3D information provided by cone beam imaging. They devised a method to aid clinicians to quickly estimate the difficulty of treatment involving impacted canines, without having to do multiple measurements of angles and distances, to relay the approximate treatment plan to

the patient .In this study, a novel measuring scale (grid-like scale) was devised of the three different views (x,y and z) in order to grade the difficulty of impaction and the potential efficacy of treatment. . Depending on its anatomical location, the cusp tip and the root tip are each given a number 0–5 in three dimensions taken from a pre treatment image. The sum of the cusp tip and root tip scores in the three views dictated the anticipated difficulty of treatment classified as easy, moderate, difficult, and nearly impossible. **Scores in the range 0–9 fall into the category of easy; 10–14 are moderate;15–19 are difficult; and 20 and above are extremely difficult.**

A simple impaction would result in a short time of treatment and may be needing basic orthodontic guidance. A moderate impaction requires longer treatment times, and an impacted canine scored as difficult would require even lengthier treatment, perhaps involving more advanced orthodontic techniques. An impaction that is classified as nearly impossible poses extreme difficulty for the orthodontist and could require the intervention of an oral surgeon before the canine can be brought into position, or the impacted tooth may simply need to be extracted.

San Martin. D.E et al[44]in the year**2012** determined whether KPG index provides an estimate of the time necessary to treat an impacted canine using closed eruption. CBCT scans of 28 impacted canines at The University of Texas School of Dentistry at Houston Department of Orthodontics were classified using the KPG index. The scores and categories were compared to the time from surgical exposure to proper positioning. They concluded that the KPG index currently

cannot be confirmed as an accurate means of estimating treatment time for an impacted canine. Further verification studies should include larger sample sizes and compare differing mechanics.

Dalessandri.D et al [45]in the year**2013** conducted a study to assess both inter and intrarater reliability of the measurements of KPG index taken on images obtained with different CBCT scanners and analyzed with different 3D visualization software. They concluded that the KPG index reproducibility is not influenced by the CBCT scanner used ,if voxel size and slice interval are equal. They demonstrated the inter and intra rater reliability was at almost perfect agreement. In this study, they proposed the operative recommendations for the better use of KPG index. In that 'Occlusal reference arch' was explained as the curved line drawn on an axial plane that passes through the centers of the clinical crowns all the teeth, when they are correctly aligned. The correct axial plane for individuating this arch is the one going through the necks of teeth. Results of this study demonstrated that software used to assess impacted canines with this index must allow to obtain an OPG-like image for evaluating$x$-and$y$-axis scores and to digitally point the starting and the ending measurement points on axial slices for evaluating$z$-axis score

Kau et al in 2013 [46]conducted a study to determine the level of agreement of orthodontists in the management of impacted maxillary canines using conventional methods and test this agreement against a novel three dimensional (3D) classification system (KPG index).In this study, 18 ectopic maxillary canines from 12 subjects were included. A panel of 55 clinicians was invited to evaluate,

for each of the 12 patients, one panoramic and one occlusal radiograph generated from the CBCT. Based on their experience, they were asked to assess the severity of canine impaction. In this study they found that the clinicians are variable in rating the complexity of canine impactions using traditional radiographic techniques and the novel KPG index shows a good level of agreement with the clinician's perception of difficulty in orthodontic cases and recommended that this index based on the 3D coordinates of the spatial arrangement of the canine may be incorporated into clinical practice.

Dalessandri et al(2014)[47] conducted a study to test the agreement between orthopantomography (OPG) based 2D measurements and the KPG index, a new index based on 3D Cone Beam Computed Tomography (CBCT) images, in predicting orthodontic treatment duration and difficulty level of impacted maxillary canines. In this study, OPG and CBCT exams of 90 subjects, 15 with bilateral impactions and 75 with unilateral impactions, coming from three different radiological centers were randomly extracted from database obtaining a sample of 105 impacted canines. There are several factors that could affect 2D images quality and accuracy, due to patient positioning errors or even to distortion effects inherent to the radiological technique used. In this study they decided to test the effectiveness of these 2D indexes; therefore, they included radiological images coming from different radiological centers, utilizing different equipment. Authors report that the reliability of OPG in the anterior maxilla is limited saying that images alteration along the horizontal plane tends to be nonlinear and also vertical measurements are not completely reliable. They said that, CBCT images are of fundamental importance in recognizing the presence of adjacent teeth root

resorption, impacted canines root anomalies, and possible overlap between canine's crown and incisor's roots. They concluded that 2D indexes for predicting impacted maxillary canines treatment duration and difficulty sometimes are discordant; a 3D index like the KPG index could be useful in solving these conflicts. Intra- and interrater agreement are higher for KPG index, when compared to these 2D indexes.

REVIEW FOR 3-D ASSESSMENT OF LATERAL INCISOR ROOT RESORPTION CAUSED BY IMPACTED CANINE

Ericson S et al [48,49]in the year**2000** conducted a study to analyze the extent and prevalence of resorption of maxillary incisors after ectopic eruption of the maxillary canines in a sample of subjects referred to an orthodontic specialist clinic for consultation. They also analyzed the ability of computerized tomography (CT) scanning to discriminate maxillary incisor root resorptions caused by ectopically erupting canines. In this study they graded the resorptions into 4 category as, *No resorption*—intact root surfaces except for the loss of cementum. *Slight resorption*—up to half of the dentine thickness to the pulp. *Moderate resorption*—resorption midway to the pulp or more, the pulp lining being unbroken .*Severe resorption*—the pulp is exposed by the resorption. This investigation showed that CT scanning is a reliable method of revealing resorptions on maxillary root incisors caused by ectopic eruption of the maxillary canines.

Ericson S et al in 2002[50]conducted a study to determine whether there is an association between widened dental follicles of the maxillary canines and resorption of the adjacent incisors during eruption. Contiguous axial (transverse) CT scans were obtained through the maxilla in the region of the canines. They concluded that the dental follicle did not cause root resorption of permanent teeth. Resorption of neighboring permanent teeth during maxillary canine eruption was most probably an effect of the physical contacts between the erupting canine and the adjacent tooth, active pressure during eruption, and cellular activities in the tissues at the contact points, all of which are part of the eruptive mechanism. The findings also confirm an association between root resorption of deciduous canines and the dental follicles of erupting permanent canines.

Liu DG et al[51]in the year 2008 conducted a study to investigate with cone-beam computed tomography (CBCT) the locations of impacted maxillary canines and resorption of neighboring incisors. The study sample comprised 175 patients with impacted or ectopically erupting maxillary canines. Two hundred ten impacted maxillary canines were analyzed using CBCT images. The locations of the impacted canines were assessed and angular and linear measurements were taken using NewTom proprietary software. In this study, we summarize these impactions into 6 variations, with an aim of convenient description of the complex locations of impacted canines. They are M-B-I,M-P-I,In situ, Distal, Horizontal and Inverted impactions. The former 4 variations depicted a mesiodistal displacement of the occlusally orientated impactions in the dental arch. In addition, horizontal and inverted impactions reflected the vertical orientation abnormality of the impactions to the dental arch. In addition, root resorption of

neighboring incisors was investigated. Root resorption was present in 27.2% of lateral and 23.4% of central incisors, and 94.3% of these resorptions occurred where the impacted canines were in close contact with the incisors. The location of impacted maxillary canines varies greatly in 3 planes, and the resorption of neighboring permanent incisors is common.[59]

Alqerban.A et al in 2009[39,12]compared the diagnostic accuracy for detection of simulated canine-induced external root resorption lesions in maxillary lateral incisors between conventional, 2-dimensional panoramic radiographic imaging and two 3-dimensional CBCT systems. The data of the this research clearly highlight the fact that the CBCT allowed validation of the impacted canine. The determination of canine location was highly significantly different between the DPT and CBCT systems because CBCT images provide applicable diagnostic information for canine location in the sagittal, axial, and coronal planes without overlap. Results suggest that the CBCT radiographic method is more sensitive than conventional radiography to detect simulated external root resorption cavities .The use of CBCTs rather than DPT imaging for the assessment of impacted canines has a potential diagnostic effect and may influence the outcome of treatment. Such a technique of free overlap may increase the interpretation of treatment outcome and treatment progress. CBCT may be a reliable method for detecting canine impaction and root resorption of adjacent teeth. A CBCT image establishes the link between 2D and 3D imaging and is more accurate for the different diagnostic tasks in canine impaction than panoramic radiography. Using CBCT with the maximum data available would help reduce unnecessary radiation exposure.

Cernochova .P et al in 2011[52]conducted a study to determine the occurrence of severe root resorption involving the pulpal canal of adjacent permanent teeth associated with ectopically erupting canines, and to verify the existence of related factors. The sample consisted of 255 consecutive Caucasian patients with ectopically erupting or impacted maxillary permanent canines. It concluded that no relationship existed between the type or side of ectopic eruption, the inclination of the longitudinal axis of the ectopic canine, and the occurrence of severe root resorption. A significant relationship existed between a buccolingual position of the ectopic canine and root resorption. Severe root resorption was most frequent for buccal canines, less often for canines within the dental arch, and least often for a palatal position of the canine crown. The most severe root resorption occurred in the apical third (57.6 per cent) and apical and middle thirds (27.1 per cent).

MATERIALS AND METHODS

Imaging System

This was a retrospective study in which records of Cone beam images were obtained from the Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai-600003.CBCT images of 28 patients taken from January 2013 to December 2013 with maxillary canine impactions were assessed out of which 15 female and 13 male in the age group of 13-28years(mean age=18 years) . A total of 42 canines were assessed with KPG index.

DICOM (Digital Imaging and Communications in Medicine) files were obtained from KODAK 9500 cone beam 3D Extraoral imaging system with a reconstruction volume of 50x37mm and a reconstructed matrix voxel of 76.5x76.5x76.5µm. The equipment had CMOS sensor technology. Exposure parameters for the patients varied from 90 kV, 10 mA with a scan time of 10.8 seconds. The impacted teeth were assessed by the 3 D volumetric image and 1 mm tomographic sections in sagittal, axial and coronal planes. The field of view was 9 x 15cm (from the bottom of the chin to the top of the jaw). Cross sectional CBCT images were evaluated for labial, mid alveolus and palatal position of the impaced canine, type of impaction, root resorption of the permanent incisors. All the images were visualized by Carestream 3D software(CS3D) on a standard15.6 inch screen with 1366 x 768 pixel resolution.

Localisation Of Impacted Maxillary Canines And Assessment Of Treatment Difficulty By KPG Index:

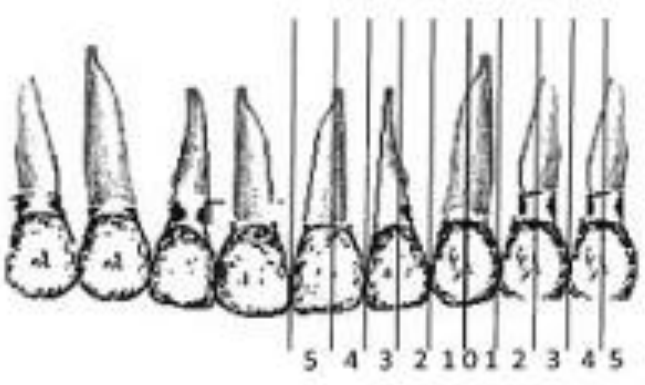
Records of 28 patients had 14 bilateral and 14 unilateral(totally 42) maxillary canine impactions. One among them had missing laterals. The relationship between the impacted canines and peripheral bony and dental structures were investigated in CBCT images. The orientation of the impacted canines were recorded as 6 types namely mesio palatal, mesio-labial, mesio-distally insitu, distal and horizontal.[51]

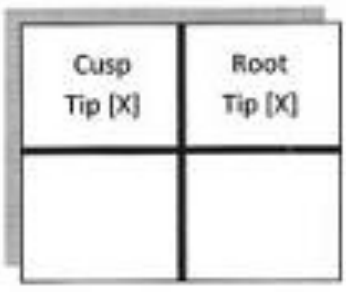
KPG INDEX

Each CBCT image was first oriented so that three planes could be constructed. Areas in X axis and Y axis are numbered in frontal view and Z axis in axial view.

X-axis:

For this scale, a traditional panoramic X-ray view is used. The impacted canine in relation to adjacent teeth are numbered as follows,



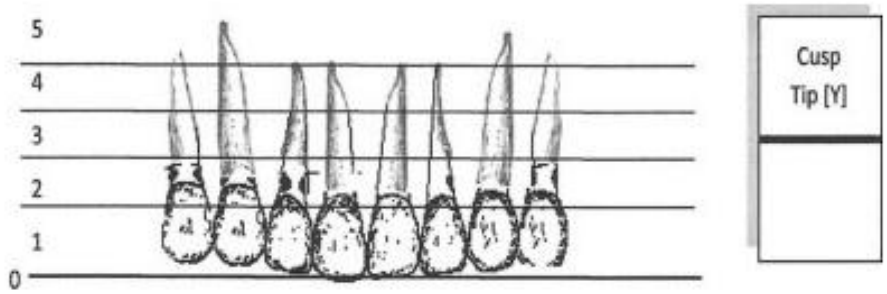


0. Canine cusp tip/root tip is in the proper erupted location; no treatment necessary in this dimension.
1. Cusp tip/root tip is within the width of the alveolus on either side of the vertical line bisecting the canine.
2. Cusp tip/root tip is in the area between the edge of the alveolus and a vertical line bisecting the adjacent tooth; either the distal half of the lateral incisor or the mesial half of the first premolar.
3. Cusp tip/root tip is in the further half of the neighbouring tooth; mesial half of lateral incisor or distal half of first premolar.
4. Cusp tip/root tip is in the distal half of the central incisor, or distal to the first premolar but mesial to the midline of the second premolar.
5. Cusp tip/root tip is in the mesial half of the central incisor or distal to the midline of the second premolar.

The y axis of locating the canine

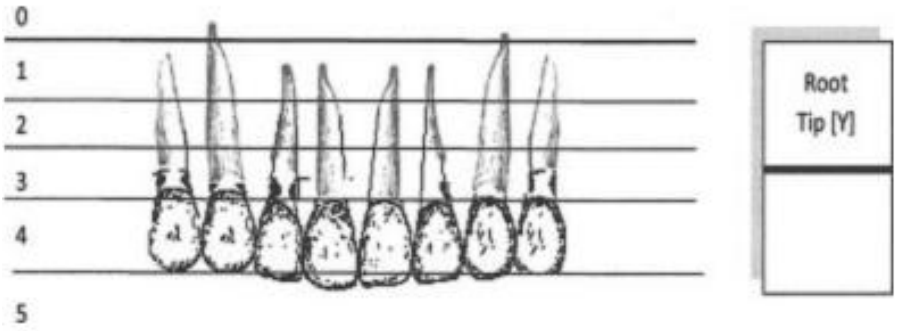
Using the same panoramic view, the height of the cusp or root tip can be determined and scaled relative to its normal developmental position. The zones for the vertical dimension are similar to those used in the study by **Liu et al**[51]: coronal, cervical one-third of the root, middle one-third of the root, apical one-third of the root, and supra-apical.

The scale for grading the canine cusp tip in the vertical dimension in the y axis is as follows



0. Canine cusp tip is in the proper vertical location.
1. Cusp tip is in the coronal region.
2. Cusp tip lies in a horizontal plane with the cervical third of the incisor root.
3. Cusp tip lies in a horizontal plane with the middle third of the incisor root.
4. Cusp tip lies in a horizontal plane with the apical third of the incisor root.
5. Cusp tip is supra apical to the incisor root.

Since the root tip and the cusp tip are at opposite ends of the tooth, the scale for the location of the root tip is almost a direct opposite of the cusp tip

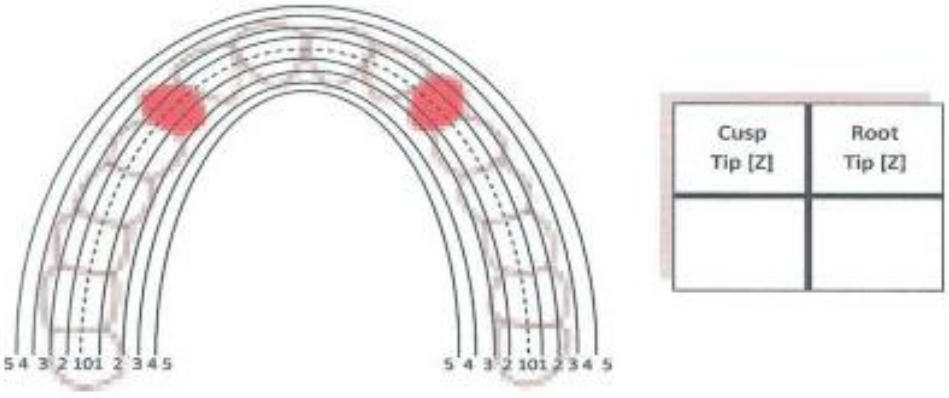


0. Canine root tip is in the proper vertical location.
1. Root tip lies in a horizontal plane with the apical third of the incisor root.
2. Root tip lies in a horizontal plane with the middle third of the incisor root.

3. Root tip lies in a horizontal plane with the cervical third of the incisor root.
4. Root tip is in the coronal region.
5. Root tip is extends past the coronal region.

The z axis of locating the canine

This was done using the axial views on the CBCT machine and makes the index unique, as this section is not normally seen with traditional radiographs. This scale uses distances measured perpendicularly in 2 mm increments from the cusp or root tip to the curved line of the occlusal arch. The divisions of the 0–5 scale are based solely on the distance of the impacted tip to the occlusal reference arch, different from the other two views, which are based more on anatomical location. In this study we devised a special grid consisting of 11 arch lines (including the midline)with 0-5 scale for viewing the position of impacted canine in axial view.



0. Canine cusp/root tip is in its proper location along the occlusal arch.
1. Cusp/root tip is 0–2.0 mm away from the occlusal arch of the cusp tip or root tip, either buccally or lingually.

2. Cusp/root tip is located in the area 2.0–4.0 mm away from the occlusal arch, either buccally or lingually.
3. Cusp/root tip is located in the area 4.0–6.0 mm away from the occlusal arch, either buccally or lingually.
4. Cusp/root tip is located in the area 6.0–8.0 mm away from the occlusal arch, either buccally or lingually.
5. Cusp/root tip is more than 8.0 mm away from the occlusal arch of the normal canine cusp or root tip, either buccally or lingually.

A score between 0 and 5 was assigned to the crown tip and for the root tip in each of the 3D views (X-, Y- and Z- axis). The final score for each tooth was obtained by adding the six sub scores for a maximum total of 30 and the degree of difficulty of treatment is categorized as, C.H.KAU et al[13] .

KPG SCORES	
EASY	0-9
MODERATE	10-14
DIFFICULT	15-19
EXTREMELY DIFFICULT	20 -30

MODIFIED KPG INDEX:

In this study modified KPG index was used to assess the 42 impacted maxillary canines Dalessandri et al[47]. In the modified version the category of easy was reduced to 0–6 scores, extending the category of moderate from 7 to 14.

MODIFIED KPG SCORES	
EASY	0-6
MODERATE	7-14
DIFFICULT	15-19
EXTREMELY DIFFICULT	20 -30

These data were recorded in Microsoft office excel.

Reliability Of KPG Index:

Three examiners were asked to independently assess these 42 canines using this KPG index(t1) after providing few guidelines in applying this index. One month later measurements were repeated(t2) by the same examiners.

Lateral Incisor Root Resorption Observation In 3D:

All images were analysed scan by scan along the root of the upper incisors, and the presence of resorptions were documented. Contact of impacted canine to the incisors and resorption of the incisor resorption of the incisors was assessed by axial and transaxial views and was graded in 1 of the following 4 categories (based on the grading system suggested by **Ericson and Kurol 2000**[49])

- no resorption: intact root surfaces
- mild resorption: resorption midway to the pulp or more, the pulp lining being unbroken
- moderate resorption: the pulp is exposed by the resorption, the involved length of the root is less than one third of the entire root

- severe resorption: the pulp is exposed by the resorption, and the involved length is more than one third of the root.

2D Measures Of Assessment Of Canine Impaction:

In order to compare the KPG index with 2D indexes, these four categories were reduced to two, creating an easy-moderate category in the range 0–14 and a difficult-very difficult category in the range 15–30.

2D measurements on OPG used to predict treatment duration or difficulty degree when planning an impacted maxillary canine orthodontic treatment were: the vertical distance from the cusp tip perpendicularly to the occlusal plane, traced from the first upper molar to the central upper incisor given by Steward et al 2001[29]and the mesio distal position of the canine tip with respect to the adjacent teeth given by Ericson et al 1988[24];Crescini et al[28] measurement was not compared with the KPG index since it was not possible to identify a cut off value between shorter and longer treatments as per Dalessandri et al 2014[47].

Statistical Analysis:

The reliability of the KPG index was tested verifying agreement between two different times for each rater (intra observer agreement) and agreement among different raters (inter observer agreement) by Cohen's kappa coefficients. Coefficients range from 0 to 1, with higher values indicating a stronger relationship: values≤0.01 indicate poor agreement, values between 0.01 and 0.20 slight agreement, between 0.21 and 0.40 fair agreement, between 0.41 and 0.60 moderate agreement, between 0.61 and 0.80 substantial agreement, between 0.81

and 0.99 almost perfect agreement, and 1 perfect agreement. All the measurements were statistically analyzed using SPSS Statistics version 22 software.

The qualitative mean results (short and long, easy or difficult) obtained from 2D and 3D agreement methods were plotted using contingency tables. Correlation between these 2D and 3D measurement were calculated using a web based calculator (http://www.medcalc.org/calc/diagnostic_test.php).

RESULTS

Patient	SEX	AGE	SIDE	TYPE	KPG SCORE	ORIGINAL KPG	MODIFIED KPG	LIRR
1	F	15	R	MB	16	DIFFICULT	DIFFICULT	MODERATE
			L	MB	16	DIFFICULT	DIFFICULT	MILD
2	F	13	L	MP	17	DIFFICULT	DIFFICULT	MILD
3	F	20	R	MP	14	MODERATE	MODERATE	NO
			L	MP	10	MODERATE	MODERATE	MILD
4	F	23	R	MP	13	MODERATE	MODERATE	MILD
			L	MP	14	MODERATE	MODERATE	MILD
5	M	24	R	Insitu	14	MODERATE	MODERATE	MODERATE
			L	Distal	14	MODERATE	MODERATE	NO
6	M	13	R	MB	12	MODERATE	MODERATE	NO
7	M	15	R	MP	12	MODERATE	MODERATE	MILD
8	M	19	R	MP	11	MODERATE	MODERATE	MILD
			L	MP	14	MODERATE	MODERATE	MODERATE
9	M	16	L	Horizontal	20	EXT-DIFFICULT	EXT-DIFFICULT	MILD
10	F	15	R	Insitu	10	MODERATE	MODERATE	NO
			L	Insitu	8	EASY	MODERATE	NO
11	F	13	R	MP	13	MODERATE	MODERATE	MODERATE
			L	MP	13	MODERATE	MODERATE	MILD
12	M	18	R	Insitu	11	MODERATE	MODERATE	MODERATE
			L	Insitu	13	MODERATE	MODERATE	MILD
13	F	15	R	Insitu	11	MODERATE	MODERATE	NO
			L	Insitu	12	MODERATE	MODERATE	NO
14	F	15	R	Insitu	6	EASY	EASY	NO
			L	Insitu	8	EASY	MODERATE	MILD
15	F	17	L	Horizontal	17	DIFFICULT	DIFFICULT	MODERATE
16	F	17	L	MP	17	DIFFICULT	DIFFICULT	SEVERE

17	M	30	R	MP	13	MODERATE	MODERATE	NO
18	F	19	L	MP	12	MODERATE	MODERATE	MILD
19	M	16	R	MB	12	MODERATE	MODERATE	MILD
			L	MP	15	DIFFICULT	DIFFICULT	NO
20	F	22	R	MP	16	DIFFICLUT	DIFFICULT	NO
21	F	16	R	Distal	11	MODERATE	MODERATE	NO
			L	Insitu	8	EASY	MODERATE	NO
22	F	17	R	Distal	12	MODERATE	MODERATE	MISSING
23	M	14	R	Horizontal	19	DIFFICULT	DIFFICULT	MODERATE
24	M	21	L	MB	12	MODERATE	MODERATE	MODERATE
25	M	14	L	MP	12	MODERATE	MODERATE	MILD
26	M	18	R	MB	15	DIFFICULT	DIFFICULT	MILD
			L	MB	17	DIFFICULT	DIFFICULT	MODERATE
27	F	24	L	MP	13	MODERATE	MODERATE	MILD
28	M	16	R	Horizontal	12	MODERATE	MODERATE	MODERATE
				Insitu	11	MODERATE	MODERATE	MILD

M=MALE MB=MESIO BUCCAL IMPACTION

F=FEMALE MP=MESIO PALATAL IMPACTION

L=LEFT EXT-DIFFICULT=EXTREMELY DIFFICULT

R=RIGHT

STATISTICAL ANALYSIS:

The statistical analysis was done using the computer software program SPSS version 22.

In the present study, ***P-value <0.05*** was considered as the level of significance. Cohen kappa coefficient was used to find inter and intra rater agreement of reliability. Chi-square tests were used to test the 2D-3D methods agreements.

One way ANOVA was used find the comparison between KPG index and LIRR.

TABLE:1 Distributieon of impacted maxillary canine based on gender

:

Gender	Number of patients (n=28)	%
Male	13	46
Female	15	54
Total	28	100

TABLE:2 Distribution of impacted maxillary canine based on unilateral and bilateral status:

Unilateral/ Bilateral	Number of Patients (n=28)	%
Unilateral	14	50
Bilateral	14	50
Total	28	100

TABLE:3 Distribution of impacted maxillary canines based on sides:

Side	Number of canines assessed (n=42)	%
Left	22	52
Right	20	48
Total	42	100

TABLE:4 Distribution of the 42 maxillary impacted canines in CBCT into six types:

Distribution of Impaction	42 Impacted Maxillary Canines						Total
	M-L-I	M-P-I	In situ	Distal	Horizontal	Inverted	
Bilateral	9	5	11	2	1	-	28
Unilateral	2	8	-	1	3	-	14
Total	11(26%)	13(31%)	11(26%)	3(7%)	4(10%)	-	42

TABLE:5 Assessment of treatment difficulty of impacted maxillary canines by KPG Index

	No of cases	
Scores	Original KPG index	Modified KPG index
EASY	4	1
MODERATE	27	30
DIFFICULT	10	10
EXT-DIFFICULT	1	1
Total	42	42

RELIABILITY OF KPG SCORES:

Intra and inter rater agreement:

TABLE:6 A)Kappa coefficients for intrarater agreement between t1 and t2

Observer	Kappa coefficient	**Standard error**
1	1.000	**0.000**
2	0.842	**0.088**
3	0.900	**0.067**

*Statistically significant association. *P-value <0.05*

B)Kappa coefficients for interrater agreement at t1 and t2

Timing	t1		t2	
Observer	Kappa coefficient	Standard error	Kappa coefficient	Standard error
1&2	0.832	0.054	0.764	0.063
2&3	0.835	0.054	0.915	0.042
3&1	0.773	0.059	0.793	0.058

*Statistically significant association. *P-value <0.05*

2D and 3D Indexes Agreement:

*TABLE :7 A)Contingency table comparing **KPG index vs Stewart's** measurement.*

KPG	Stewart		Total
	Shorter	Longer	
Shorter	26	5	31
Longer	3	8	11
Total	29	13	42

Chi-square tests:

	Value	P value
Yates correction	9.665	0.0019
Positive likelihood ratio	2.33	
Negative likelihood ratio	0.17	
Sensitivity	89.66%	
Specificity	61.54%	
Positive predictive value	83.87%	
Negative predictive value	72.73%	

*Statistically significant association.

TABLE :7 *B) Contingency table comparing* ***KPG index vs Ericson and Kurol*** *analysis:*

KPG	Ericson and Kurol		Total
	Easy	Difficult	
Easy	12	19	31
Difficult	0	11	11
Total	12	30	42

Chi-square tests:

	Value	P value
Yates correction	4.215	0.0401
Positive likelihood ratio	1.58	
Negative likelihood ratio	0.00	
Sensitivity	100%	
Specificity	36.67%	
Positive predictive value	38.71%	
Negative predictive value	100.00%	

*Statistically significant association.

Table: 7 C) Contingency table comparing ***Stewart vs Ericson and Kurol*** analysis:

Stewart	Ericson and Kurol		Total
	Easy	Difficult	
Shorter	12	17	29
Longer	0	13	13
Total	12	30	42

Chi-square tests:

	Value	P value
Yates correction	5.640	0.0176
Positive likelihood ratio	1.76	
Negative likelihood ratio	0.00	
Sensitivity	100%	
Specificity	43.33%	
Positive predictive value	41.38%	
Negative predictive value	100.00%	

*Statistically significant association.

ASSESSMENT OF LATERAL INCISOR ROOT RESORPTION:

TABLE :8 Contact Relationship between the 42 impacted maxillary canines and adjacent incisors assessed on CBCT:

	Contact		
Teeth	No	Yes	Total
Lateral Incisor(1 missing)	5 (12%)	36 (88%)	41
Central Incisor	17 (40%)	25 (60%)	42

TABLE:9 Resorptions grades on the roots of the Maxillary Incisors adjacent to 42 impacted Maxillary canines shown on CBCT:(Ericson and Kurol 2000)

Teeth	Root Resorption				
	No	Slight	Moderate	Severe	Total
Lateral Incisor (1 missing)	13 (32%)	17 (42%)	10 (24%)	1 (2%)	41
Central Incisor	32 (76%)	6 (14%)	2 (5%)	2 (5%)	42

TABLE:10 Contact relationship between incisors and impacted canines and distribution of resorption in the central and lateral incisors

Type of resorption	Lateral Incisor (1 Missing)		Central Incisor	
	No contact	Contact	No contact	Contact
No	5	8	17	15
Mild	-	17	-	6
Moderate	-	10	-	2
Severe	-	1	-	2
Total	5	36	17	25
	41		42	

CROSS TABLES:

TABLE:11 Comparison of Lateral Incisor root resorption grades with KPG Scores:

LIRR	KPG				Total
	Mild	Moderate	Difficult	Severe	
No	1	10	2	-	13
Mild	-	13	3	1	17
Moderate	-	6	4	-	10
Severe	-	-	1	-	1
Total	1	29	10	1	41

*Missing Lateral Incisor =1

TABLE:12 A) Descriptive statistics of KPG and LIRR

LIRR	N	Mean KPG	Std. Deviation	Minimum	Maximum
No	13	11.54	2.961	6	16
Mild	17	13.06	2.794	8	20
Moderate	11	14.73	2.611	11	19
Total	41	13.02	2.996	6	20

B)ANOVA Table

Sum of Squares		df	Mean Square	F-Value	P-Value
Between Groups	60.622	2	30.311	3.861	.030
Within Groups	298.354	38	7.851		
Total	358.976	40			

C) Tukey HSD Post Hoc Tests for multiple comparison

LIRR		Mean Difference	P-Value
No	Mild	-1.520	0.315
	Moderate	-3.189	0.022
Mild	Moderate	-1.668	0.285

D) Homogeneous Subsets for KPG SCORE

LIRR	N	Subset for alpha	
		1	2
No	13	11.54	
Mild	17	13.06	13.06
Moderate	11		14.73

.

CHARTS:

CHART 1.Distribution of impacted maxillary canine based on gender:

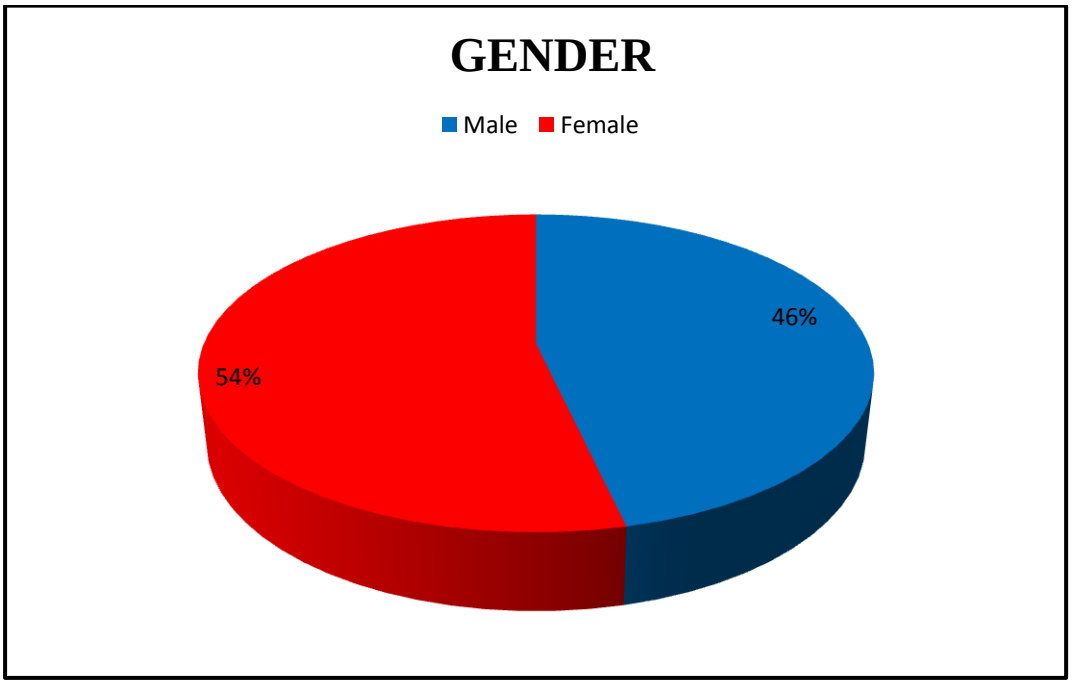


CHART 2.Distribution of impacted canine on the maxillary arch:

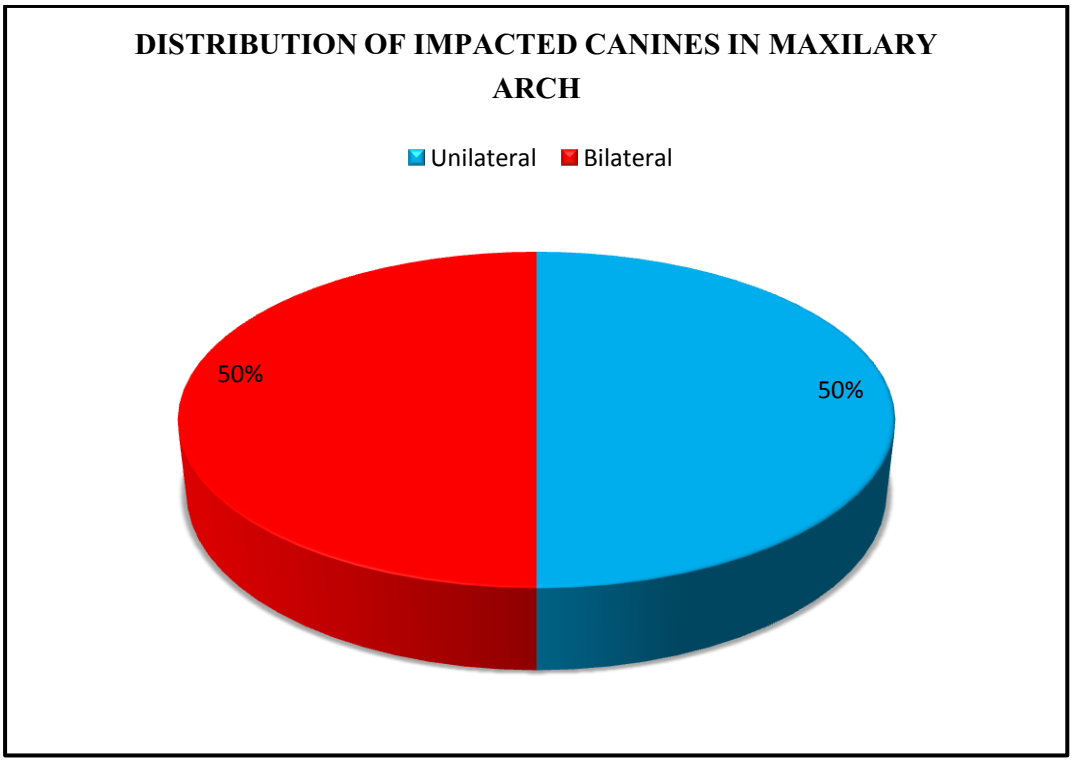


***CHART 3.Distrubution of impacted maxillary canines based on side*:**

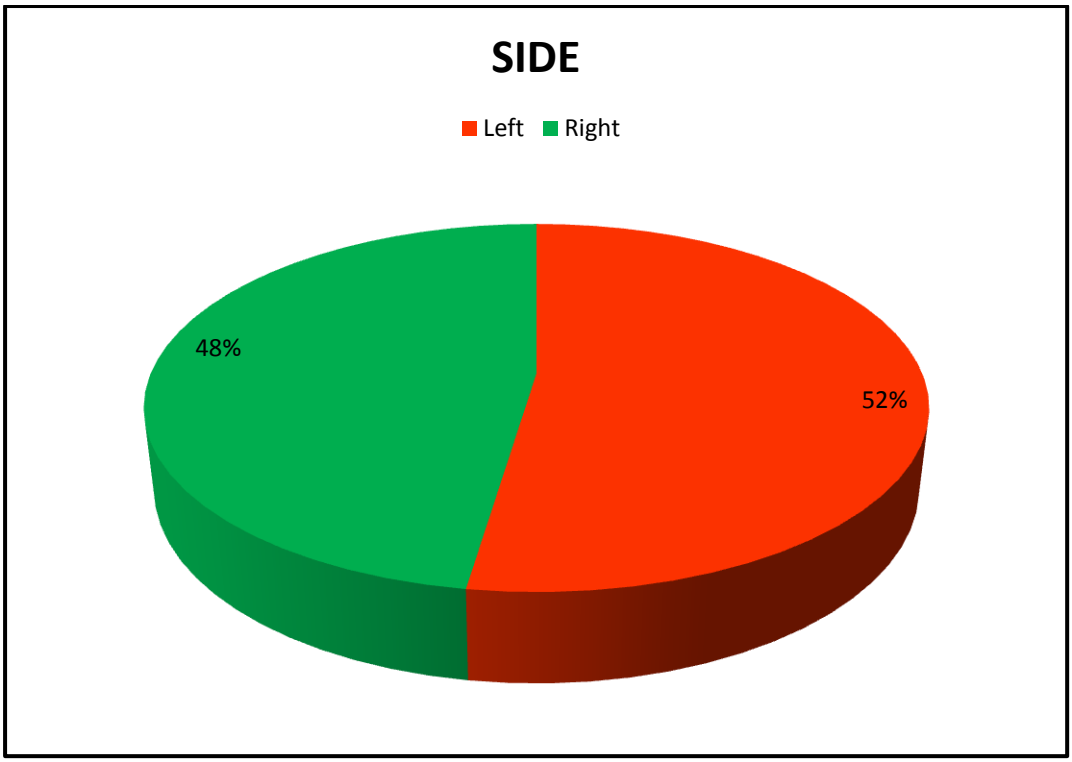


CHART 4.Distribution of maxillary canine impactions in CBCT into six types given by Liu et al [51]**:**

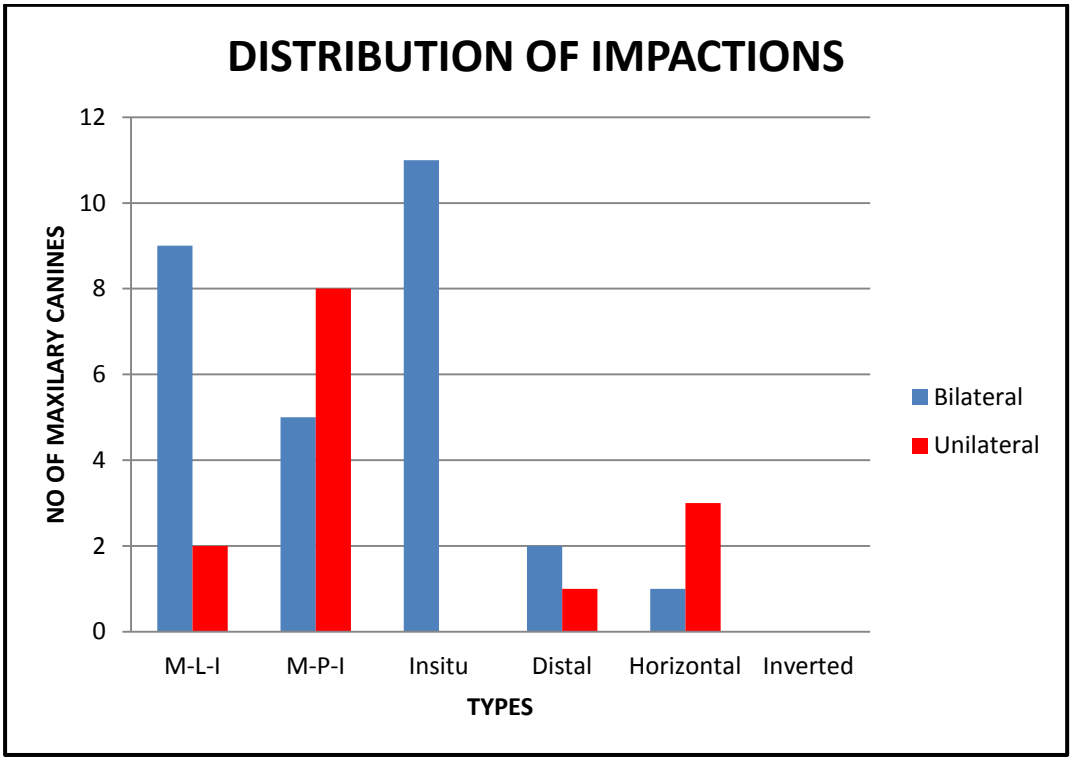


CHART 5.Contact Relationship between the impacted maxillary canines and adjacent incisors assessed on CBCT

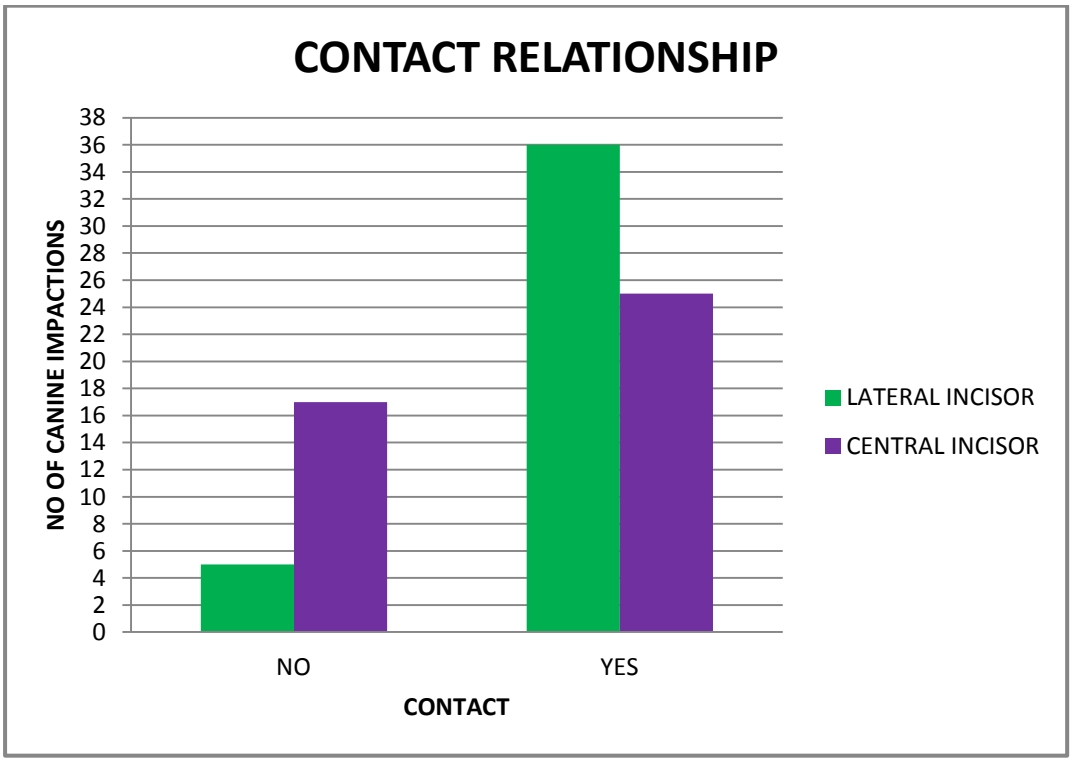


CHART 6. Resorptions grades on the roots of the Maxillary Incisors adjacent to 42 impacted Maxillary canines shown on CBCT:(Ericson and Kurol 2000)[49]

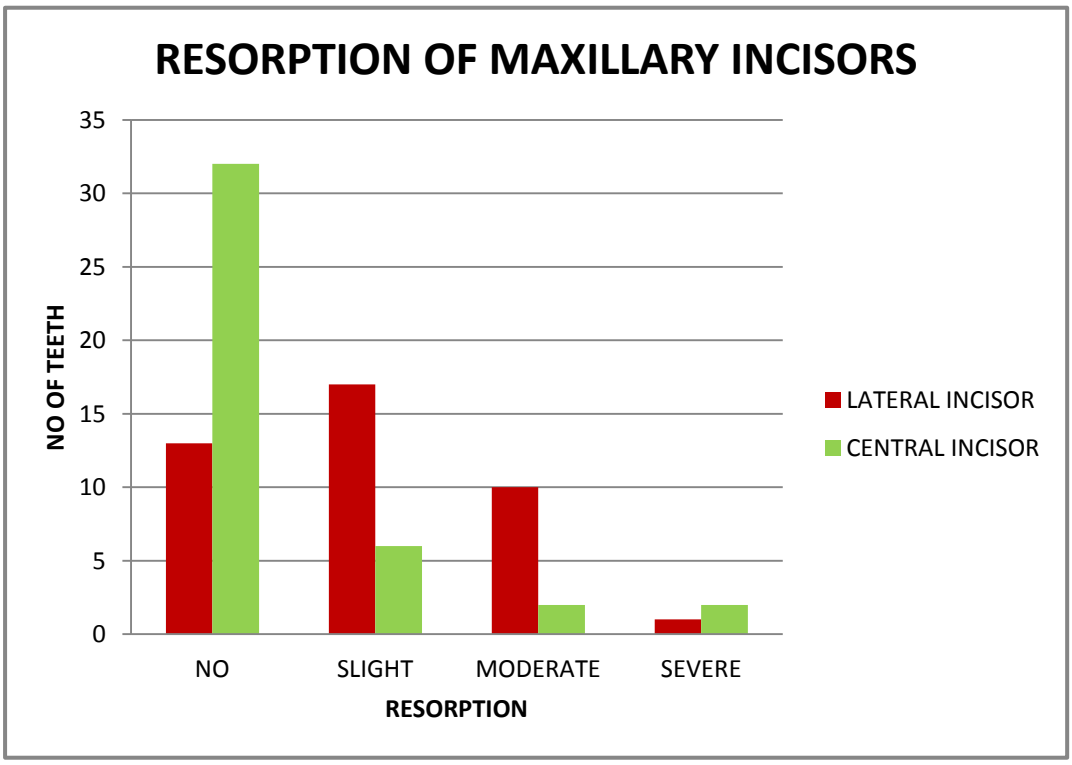


CHART 7. Comparison of Lateral Incisor root resorption grades with mean KPG Scores:

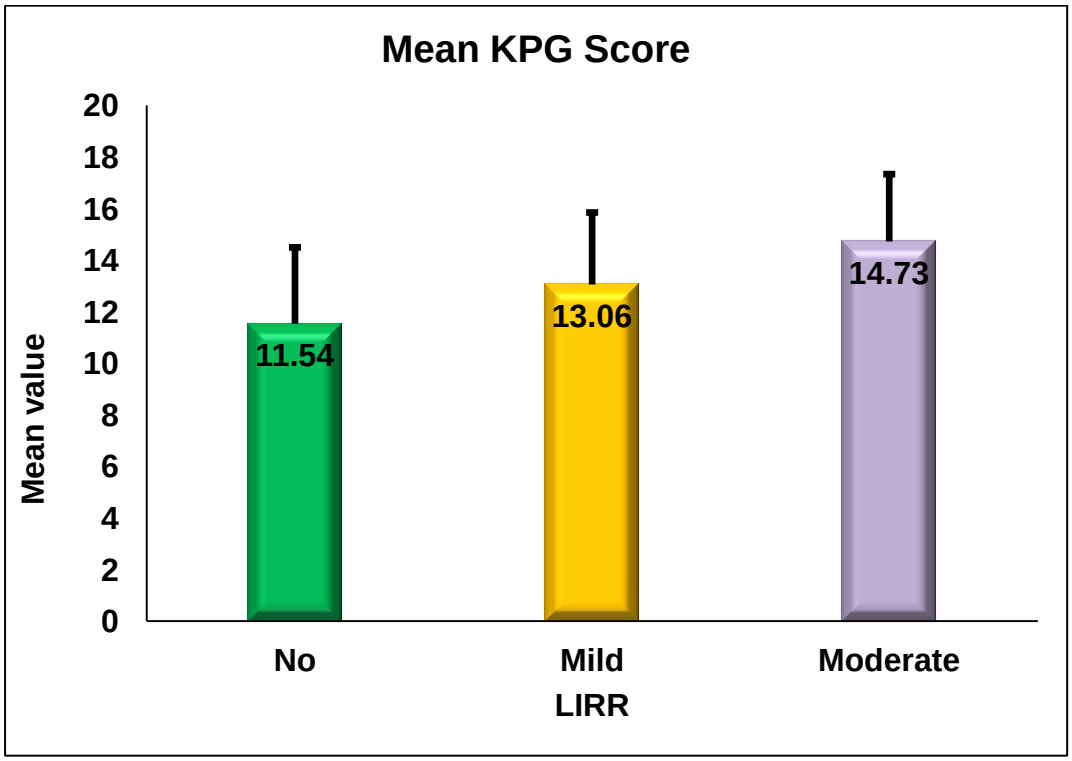


Table 1 and chart 1 showing the distribution of impacted maxillary canine based on gender. Out of 28 patients 15 (54%) were female and 13(46%) were male.

Table 2 and chart 2 showing the distribution of impacted canines in the maxillary arch. Out of 28 patients 14 (50%) were unilateral and 14(50%) were bilaterally impacted maxillary canine.

Table 3 and chart 3 showing the distribution of impacted maxillary canine based on the sides. Out of 42 cases 22 (52%) were left side and 20(48%) were right side.

Table 4 and chart 4 showing the distribution of impacted maxillary canines in mesiodistal and vertical displacement in the dental arch in CBCT. Out of 42 impactions 13(31%)were M-P-I, 11(26%) were M-L-I and Insitu each, 3(7%) were Distal,4(10%) were Horizontal. No inverted impactions.

Table 5 shows distribution of number of cases by original and modified KPG index as easy, moderate, difficult and extremely difficult in the treatment of impacted maxillary canines.

Table 6 A) shows kappa coefficients between t1 and t2 considering each rater individually. They range from 0.842 to 1, statistically indicating almost perfect or perfect intra rater agreement.

B) shows kappa coefficients between 3 observers at t1 and t2.Values range from 0.773 to 0.835 at t1 and 0.764 to 0.915 at t2 which demonstates substantial or almost perfect inter rater agreement.

Table 7 A)shows the comparative results regarding the prediction of treatment duration with KPG index and Stewart's measurement of canine's cusp tip vertical distance from occlusal plane. Considering Stewart's measurement as the reference standard, the sensitivity of KPG index was 89.66% , while the specificity was 61.54% and negative predictive values was 72.73%. There was a statistically significant level($P < 0.0019$) results obtained with Yates correction of 9.665.

Table 7 B) shows the comparative results regarding the prediction of treatment difficulty degree with KPG index and Ericson and Kurol's analysis of canine's cusp tip position relative to the lateral incisor bisecting axis. Considering Ericson and Kurol's analysis as the reference standard, the sensitivity of KPG index was 100%, while the specificity and negative predictive values were 36.67% and100%, respectively. There was a statistically significant ($P < 0.05$) results obtained with Yates correction of 4.215.

Table 7 C) shows the comparative results between Stewart's measurement and Ericson and Kurol's analysis. Considering Ericson and Kurol's analysis as the reference standard, the sensitivity of Stewart's measurement was 100%, while the specificity and negative predictive values were 43.33% and 100%, respectively. There was statistically significant (P=0.0176) association between the results obtained with both analyses, with Yates correction of 5.640.

Table 8 and chart 5 shows contact relationship between impacted maxillary canines and adjacent incisors on CBCT. Out of 42 cases 36(88%) had contact between canines and lateral incisor.5(12%) had no contact. In one case lateral incisor was missing. Regarding central incisor, out of 42 cases,25(60%) had contact with impacted canines.17(40%)of cases, did not have contact relationship.

Table 9 and chart 6 shows the grading of incisor root resorption adjacent to impacted maxillary canines assessed 3-dimensionally by CBCT. Out of 41 lateral incisor which had contact with impacted maxillary canine,13(32%) had no resorption,17(42%) had slight,10(24%) had moderate and only 1(2%) had severe

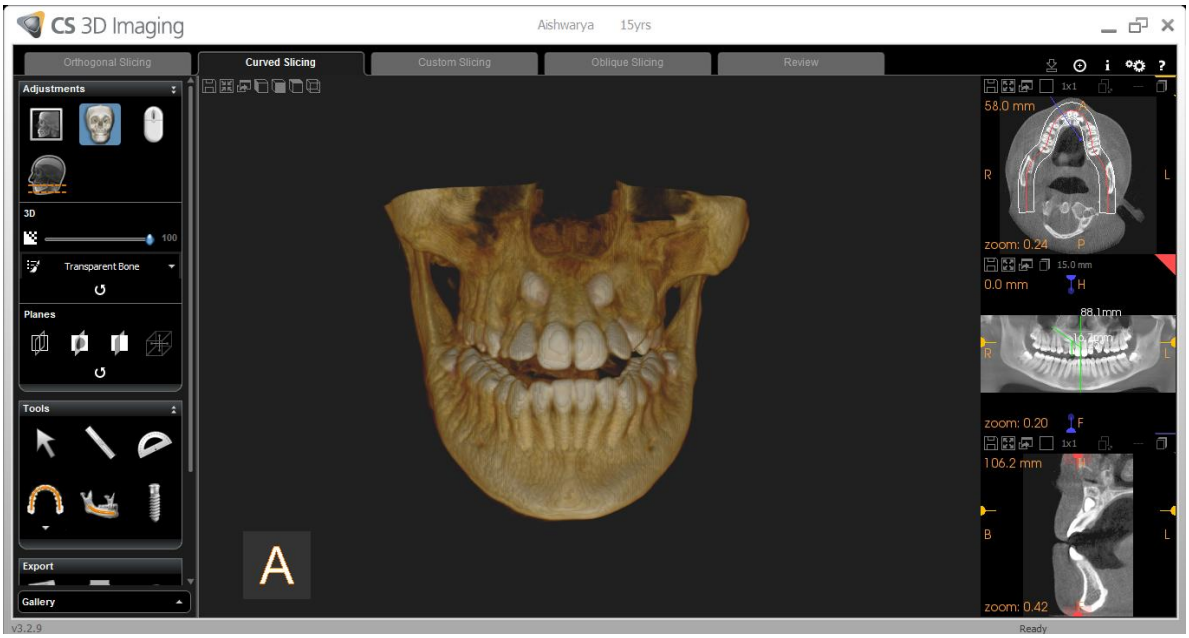
root resorption. Out of 42 central incisors 32(76%) had no contact,6(14%)had slight, 2(5%) had moderate and 2(5%) had severe root resorption.:

Table 10 shows the distribution of root resorption of maxillary incisors and contact relationship with impacted maxillary canines. Out of 36 lateral incisor contacts, mild and moderate root resorption was common about 17 and10 respectively. Severe was very scarce and 8 had no root resorption. Out of 25 central incisor contacts majority had no resorption, 6 had mild, 2 had moderate, and 2 had severe.

Table 11 shows the distribution of various grades of LIRR among 4 scores(mild, moderate, difficult, severe) of KPG index. Since each score of KPG index namely mild(0-6), moderate(7-14),difficult(15-19) and severe(20-30) comes in a range of values but LIRR comes in 4 qualitative grades, in this study we conducted one way ANOVA to compare the mean KPG Score between LIRR .

Table 12 and chart 7 shows LIRR varies statistically significant with mean KPG. **Chart 7** shows that as mean KPG increases lateral incisor root resorption also increases.

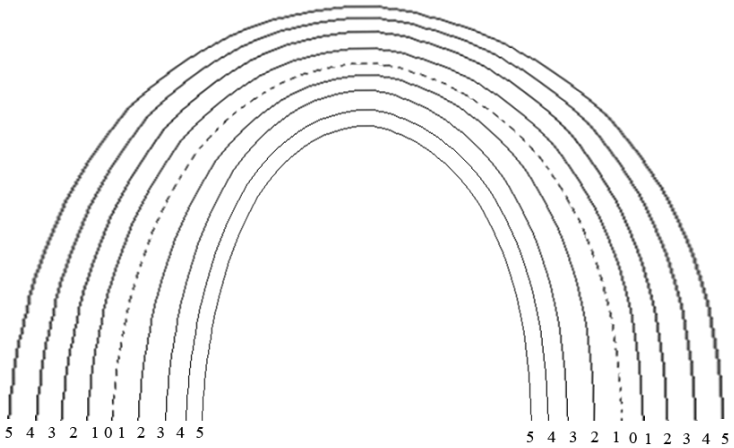
CS 3D IMAGING SOFTWARE



2-D OPG VIEW FROM CS 3D IMAGING SOFTWARE

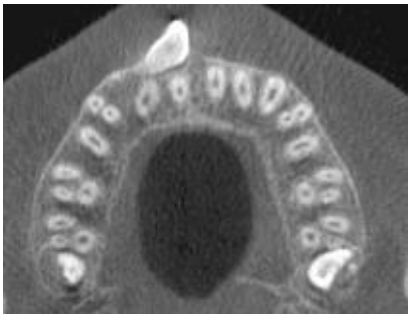
OCCLUSAL REFERENCE ARCH FORM IN AXIAL VIEW

AXIAL GRID USED IN KPG INDEX TO LOCATE THE CANINE

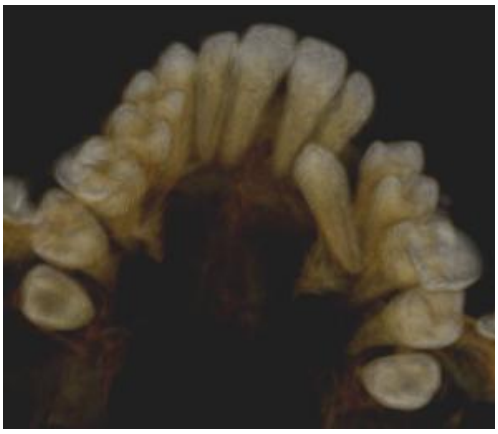


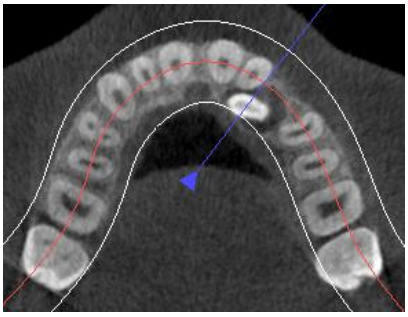
TYPES OF CANINE IMPACTION

1.MESIO LABIAL IMPACTION(M-L-I)

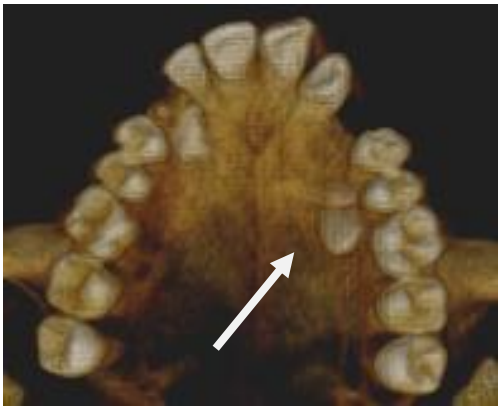


2.MESIO PALATAL IMPACTION(M-P-I)

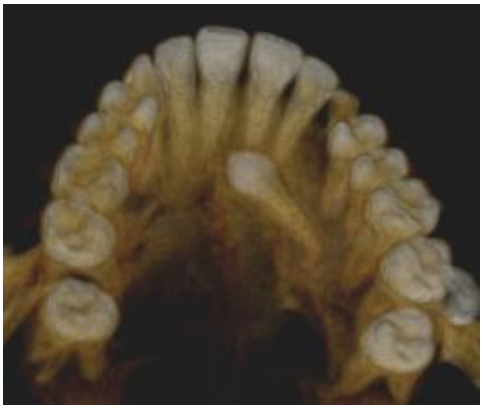




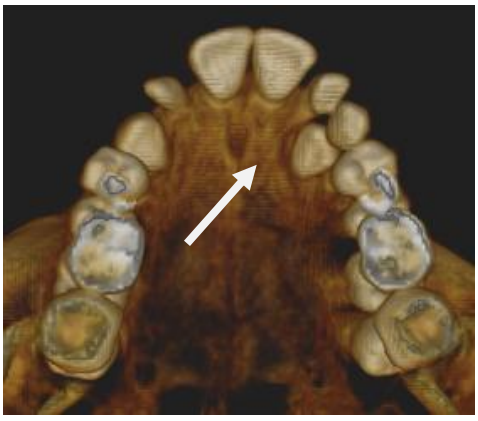
3.DISTAL IMPACTION

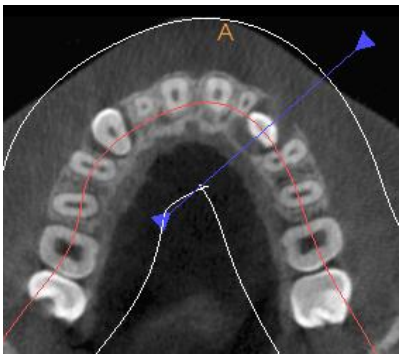


4.HORIZONTAL IMPACTION

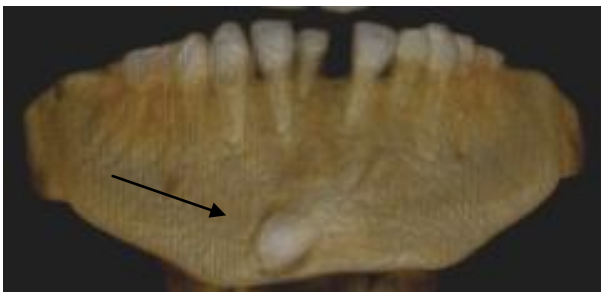


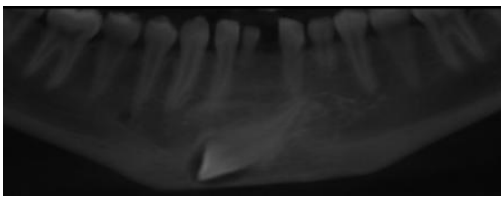
5.INSITU IMPACTION



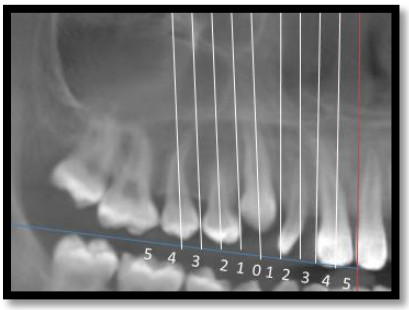


6.INVERTED IMPACTION

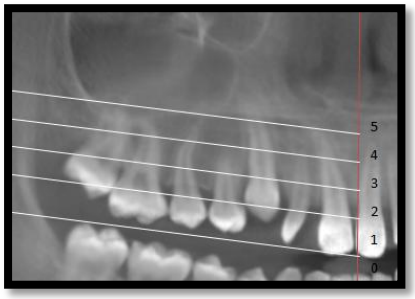




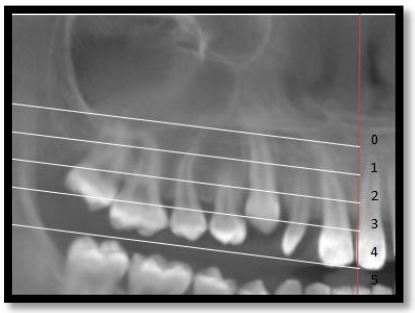
KPG INDEX ASSESSMENT - **EASY**



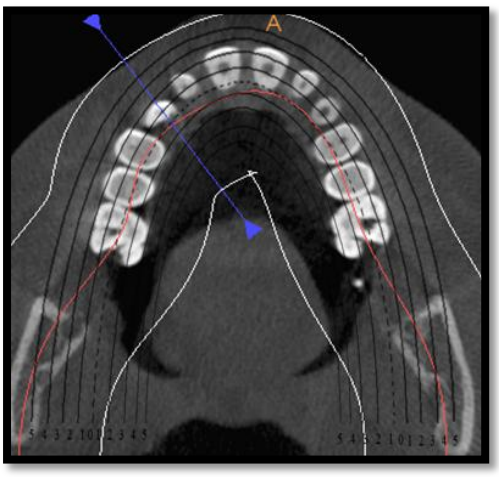
Cusp Tip(X)	Root Tip(X)
0	1



Cusp Tip(Y)
1

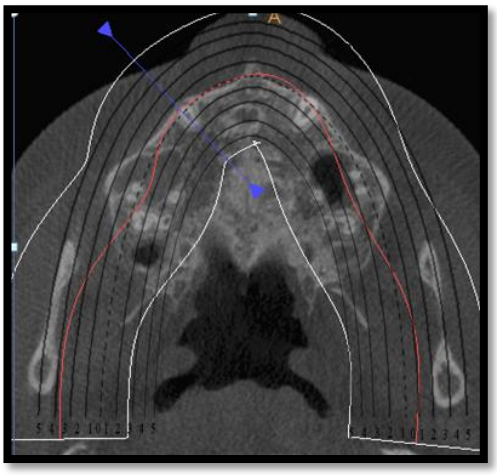


Root Tip(Y)
0



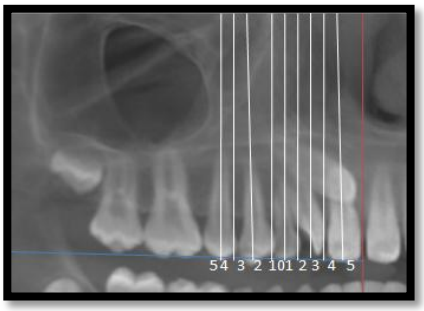
Cusp Tip(Z)
2

Root Tip(Z)
2

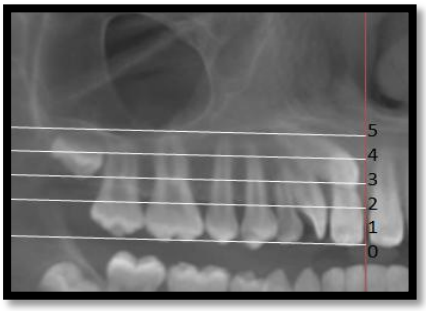


KPG INDEX SCORE=6

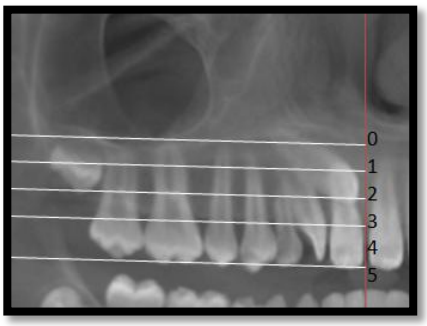
KPG INDEX ASSESSMENT - **MODERATE**



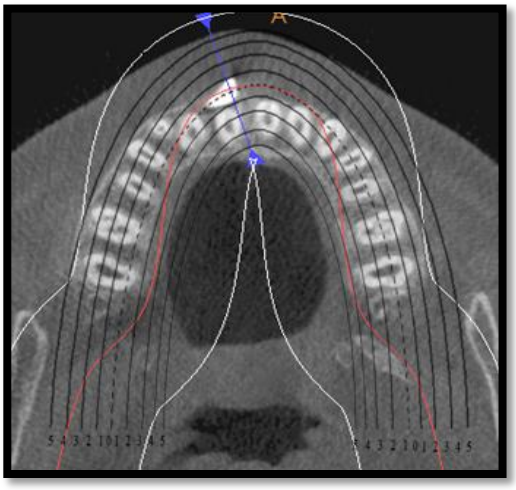
Cusp Tip(X)	Root Tip(X)
5	0



Cusp Tip(Y)
3

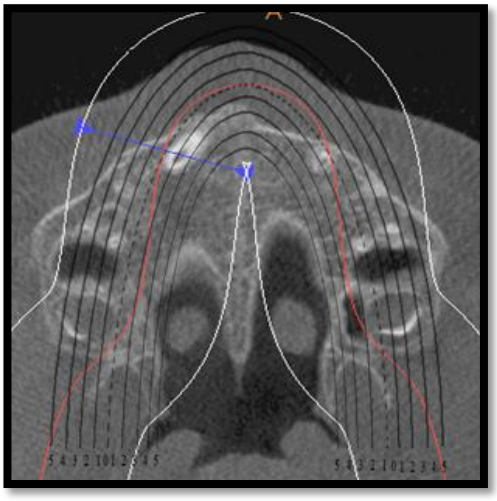


Root Tip(Y)
0



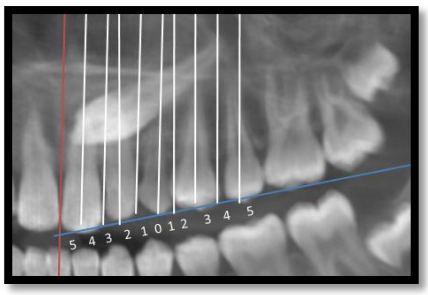
Cusp Tip(Z)
2

Root Tip(Z)
2

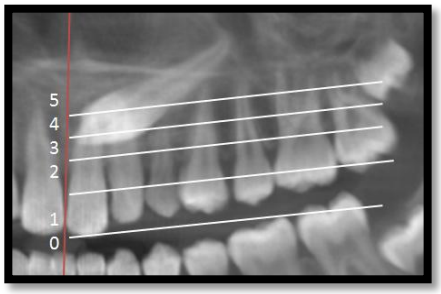


KPG INDEX SCORE=12

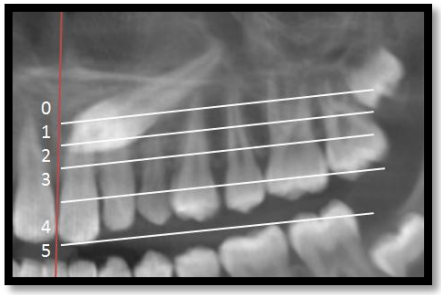
KPG INDEX ASSESSMENT - **DIFFICULT**



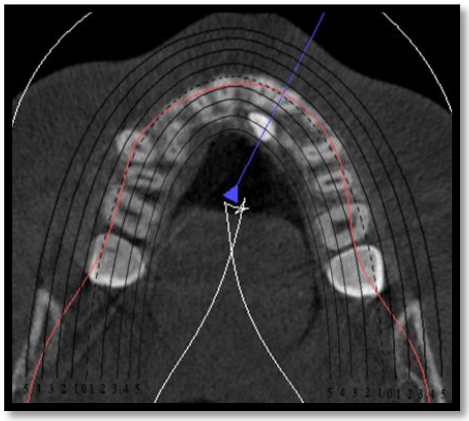
Cusp Tip(X)	Root Tip(X)
5	5



Cusp Tip(Y)
3

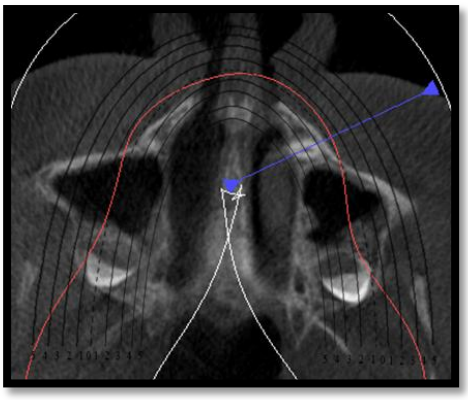


Root Tip(Y)
0



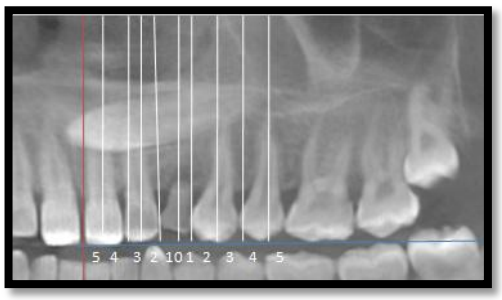
Cusp Tip(Z)
3

Root Tip(Z)
2

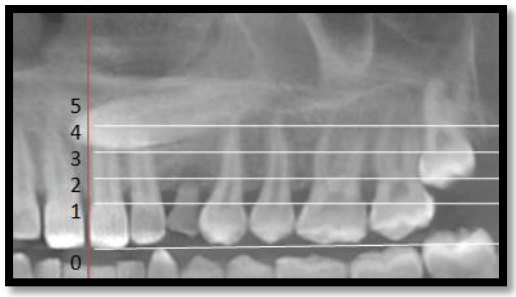


KPG INDEX SCORE=18

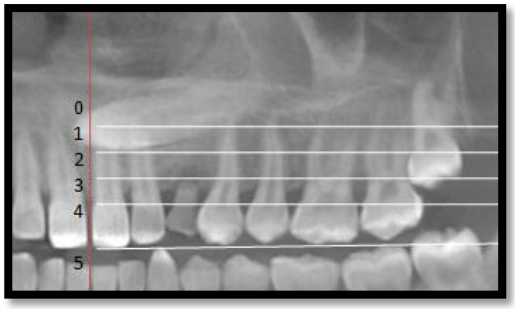
KPG INDEX ASSESSMENT - **EXTREMELY DIFFICULT**



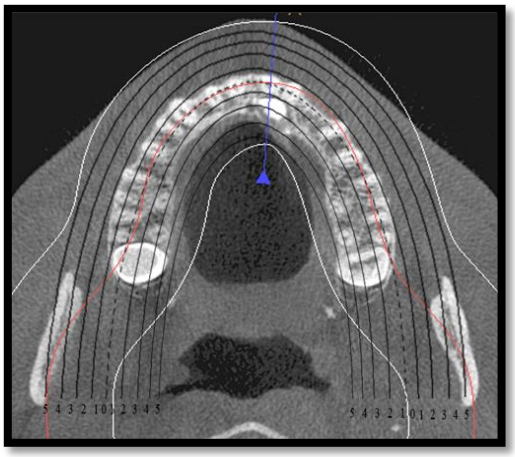
Cusp Tip(X)	Root Tip(X)
5	5



Cusp Tip(Y)
4

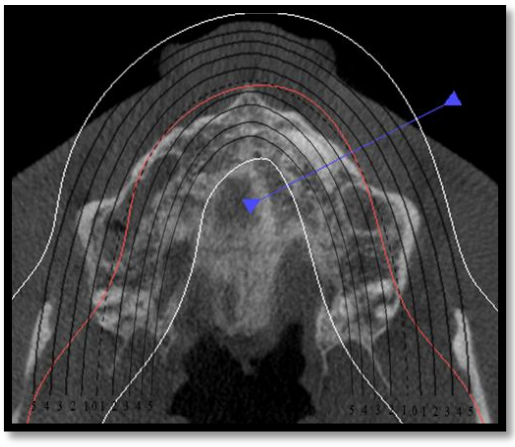


Root Tip(Y)
0



Cusp Tip(Z)
3

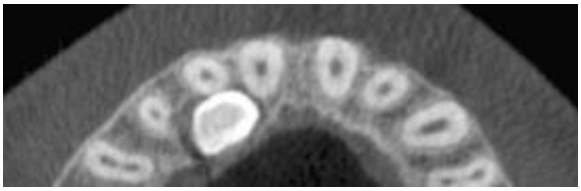
Root Tip(Z)
3



KPG INDEX SCORE=20

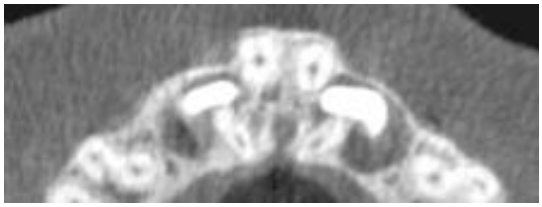
GRADES OF ROOT RESORPTION IN 3D IMAGING

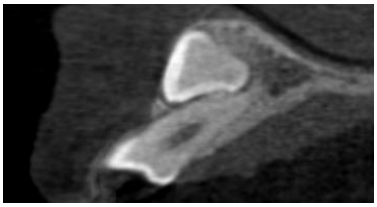
1.NO RESORPTION

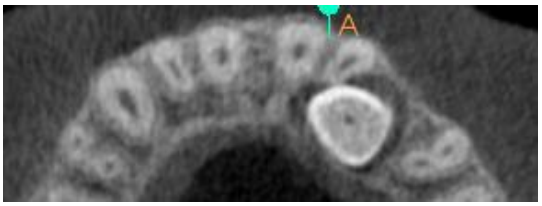


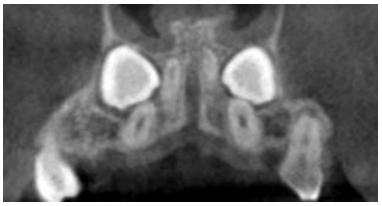
NO RESORPTION- intact root surfaces.The cementum layer may be lost.

2.MILD RESORPTION



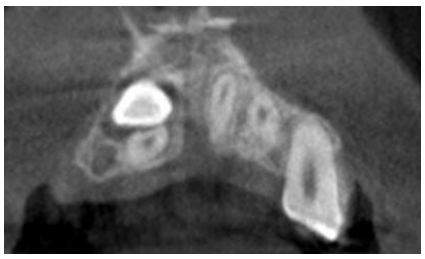
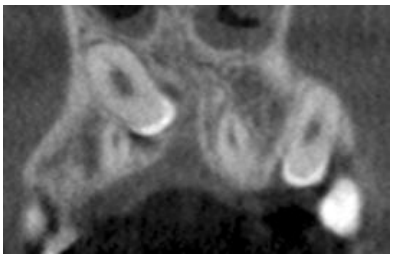
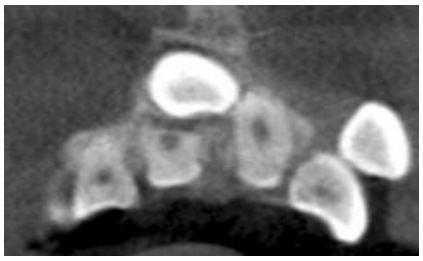
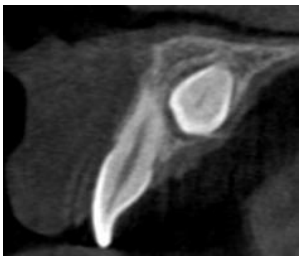






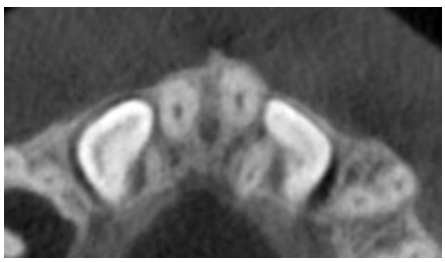
MILD RESORPTION- upto half of the dentine thickness to the pulp.

3.MODERATE RESORPTION

MODERATE RESORPTION- resorption midway to the pulp or more,the pulp lining being unbroken and the involved length of the root is lesss than one third of the entire root.

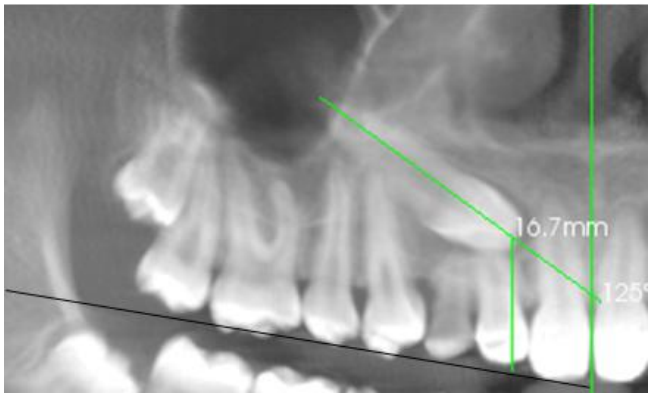
4.SEVERE RESORPTION



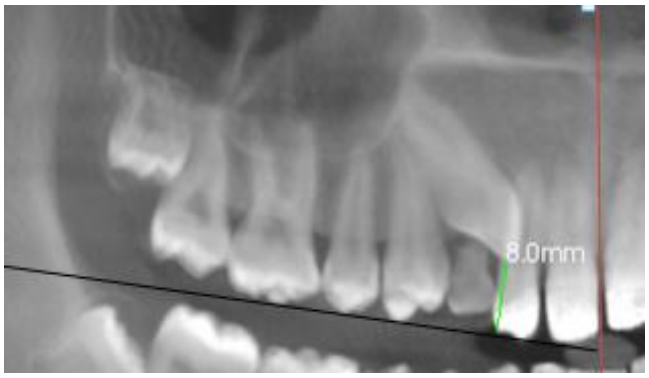

SEVERE RESORPTION- the pulp is exposed by the resorption and the involved length is more than one third of the root.

2-D ASSESSMENT METHODS

STEWART ANALYSIS

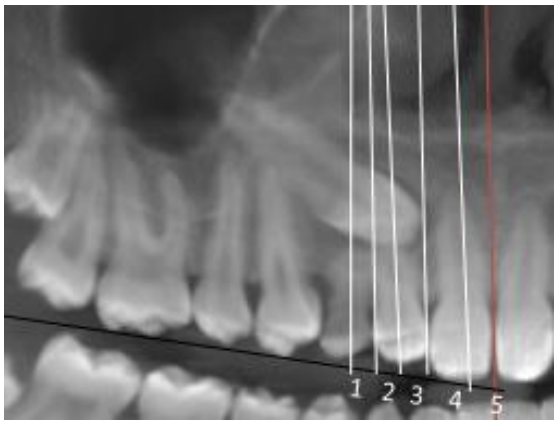


Vertical distance from the cusp tip perpendicularly to the occlusal plane, traced from the first upper molar to the central upper incisor. In this example,16.7 mm, corresponds to a longer treatment.



In this example, 8.0 mm, corresponds to a shorter treatment.

ERICSON AND KUROL ANALYSIS:



DISCUSSION

Impaction is a pathological condition which is defined as “lack of eruption of a tooth in the oral cavity within the time and physiological limits of normal eruption process”.[1] “Impacted teeth can be defined as those teeth that are prevented from eruption due to a physical barrier within the path of eruption”[53].Maxillary canines have the highest frequency of impacted localization after the third molars, with a prevalence ranging from 1% to 3%, and with a 2:1 female to male ratio.[54]

The term “localization” means “determination of the site or place of any process or lesion”.[55]Accurate knowledge of the position of an impacted canine may contribute to the decision to perform a less invasive procedure when exposure of the canine is required. The use of various techniques, including the parallax method , vertex occlusal radiography, radiographic views taken at contrasting angles, stereoscopy , pantamography, the multiple exposure method, image superimposition, and computed tomography has been advocated for localization.[56]Three-dimensional views acquired by cone beam computed tomography (CBCT) have been introduced because of the improbability and limitations of 2-dimensional plain radiography.[57] Also the prognosis of an impaction can be assessed accurately only when the exact position of an impacted tooth and its relationship with the surrounding anatomical structures is well known.

The utilization of a three-dimensional CBCT image in this study for evaluation of impacted canines proved to be very useful. It provided accurate localization of the tooth, adjacent teeth, and anatomical landmarks. As stated earlier, the weaknesses of two dimensional radiographs are well documented in the literature. The use of CBCT images is now the gold standard because it provides clear 3D images which allow for accurate reproducibility of linear and angular measurements for research purposes without as much error.[39]

The present study was aimed to assess the degree of difficulty for the treatment of impacted maxillary canines using KPG index , to analyse the lateral incisor root resorption using CBCT, to add increased validation to this index ,to find the inter and intra rater reliability of this index and to compare with the 2D measurements.

A total of 28 patients (15 females and 13 males) were included in the study, age group ranging from 13 to 32 years (mean age = 18 years) and a total of 42 impacted maxillary canines were assessed in the study. Out of 28 patients 14(50%) patients had unilateral and 14(50%) patients had bilaterally impacted maxillary canines **(Table 1, 2 and Chart 1, 2).** Syryńska M et al (2008)[58] found that impacted maxillary canines were more common among females which was in accordance to our study where we found 54% of our study patients were female and 46 % were males. A study done by Ericson S, Kurol J (2000)[49] and Dachi et al (1961)[59] reported that the prevalence of impacted maxillary canines varies from 1% to 3% and also they were mostly seen in females rather than males. In our study similarly the majority of patients were female which may be due to the

differences in craniofacial growth and development factors between both sexes. In this study out of 42 impacted canines 22 (52%) were left side IMC and 20(48%) were right side IMC**.(Table 3)**

In this study, we classified impacted canines into 6 variations with an aim of convenient description of the complex locations of impacted canines as given by Liu et al[51].Buccal, palatal, mid alveolus and distal depict mesio distal displacement of the occlusally oriented impactions in the dental arch. Horizontal and inverted impactions reflect the vertical orientation abnormality of the impactions to the dental arch. Among these impactions 31% were M-P-I, 26% were M-L-I,26% were Insitu,7% were Distal and 10% were Horizontal impactions. No reported inverted impactions in this study. Mesio palatal impaction (M-P-I) is more common than Mesio labial impaction (M-L-I) and Insitu impactions. Distal and horizontal impactions were scarcely reported**.(Table 4,Chart 4)**

Orthodontic treatment of impacted canines requires accurate localization to surgically expose and retrieve each tooth most efficiently, individualizing clinical approach and mechanics[42]. Simple classifications such as two‐dimensional (2D) classifications of canine impactions have been developed. These often require a second radiograph to be taken. CBCT, maintaining the ability to eliminate the overlapping of contiguous structures, to precisely detect root resorption of adjacent teeth, and reducing the radiation dose if compared with conventional CT , is currently suggested to be the most suitable radiological exam when treating impacted canine patients.

In 2009, a novel method of analyzing maxillary canine impactions was proposed, the KPG index[13].The KPG Index allows the clinician to score the position of a canine crown and root on a CBCT in the three dimensions of space. The KPG index was proposed as a simple method to locate and assign a difficulty score to impacted maxillary canines using CBCT. Particularly, the Z-axis view shows the distance of the canine crown or root tip relative to its ideal position on the maxillary arch.

In our study,42 impacted maxillary canines were assessed by original and modified KPG index. Number of cases with 'easy' score was 4 in original version and 1 in modified KPG, with 'moderate' score was 27 in original ,and 30 in modified version, with 'difficult' score was 10 in both original and modified ,and 'extremely difficult' score to 1 impaction in both the versions.**(Table5).**We have taken the scores of 'modified version' of KPG index for further analyses in our study.

It is of crucial importance to evaluate the validity and reproducibility of this new clinical index. Validity of this index can be confirmed only by prospective studies in estimating individually treatment time necessary to bring the canine to its proper position. Hence in our study, the first aim was to assess the reproducibility of this KPG index i.e., whether this index is really easy to score and gives repeatable results when the same patient is assessed by different operators or by the same operator in different sessions.

In this study we found inter and intra rater agreement of this KPG index between three observers and it showed statistically significant association with a P value of <0.05. Intra rater agreement was 'almost perfect' to 'perfect' whereas inter rater was 'substantial' to 'almost perfect' agreement, thus demonstating the reliability of this index **(Table 6 A&B)** as shown by Domenico et al 2013[45]. Reliability of this KPG index with 2D measures was also found. Chi-square tests between 2D-3D measures were statistically significant with a P value <0.05. KPG index with Steward analysis had 89% of sensitivity, where as KPG index with Ericson and Kurol analysis and Steward analysis with Ericson and Kurol had 100% sensitivity.KPG index had a negative predictive value with Steward's analysis of 72.73% whereas with Ericson and Kurol it was 100%.In this study the concordance between KPG and Steward's analysis was weaker compared with Ericson and Kurol's **(Table 7 A,B,C).** This results are in accordance with the findings of Domenico et al(2014)[47].

Resorption on the roots of the maxillary incisors is often difficult to diagnose on intraoral films or on orthopantomograms, especially when the dentine loss is located buccally or lingually. The CT method has been proven to be most effective in revealing the presence and degree of root resorptions on teeth adjacent to ectopically erupting maxillary canines[48].In recent years , cone beam computed tomography(CBCT)which have been developed with significantly decreased radiation doses adds useful information regarding the condition of the adjacent root and is valuable in the detection of root resorption associated with impacted canines [12]. A routine panoramic radiograph could impossibly show that detailed information because of its 2D limitations, inherent deformation, and low resolution.

The mechanism of the root resorption following maleruption and the factors involved in the process are not clear. The high frequency of close contacts between the crowns of the ectopically positioned canines and the resorption cavities on the adjacent incisors in the study of Ericson and Kurol[48] indicates that the resorption is mainly caused by contact relations and physiological pressure after the eruption of the canine. In this study we found not only the occurrence of root resorption but also evaluated the extent of root resorption in CBCT based on the grading system given by Ericson and Kurol[48].Incisor contacts in this study was present in 88% of lateral incisors and 60% of central incisors**.(Table 8)**

In this study considering the contact with impacted canine, 28 out of 36 lateral incisor and 10 out of 25 central incisors had root resorption**(Table 10).** Root resorption was graded as no, slight, moderate and severe. Out of 41 laterals 17(42%) had slight,10(24%) had moderate and only 1(2%) had severe root resorption. Amongst Central incisor 6(14%)had slight, moderate and severe resorption were 2(5%) each**.(Table 9)** The resorptive cavities were mainly located on the middle and apical thirds of the root.

The lateral incisors were the teeth most affected and were more resorbed than the central incisors. Using the sector analysis in the conventional 2D orthopantomograph, prediction of lateral incisor root resorption has been reported in the literature[60]. The KPG index is the first 3-D canine classification system..The scores of KPG index indicates the level of difficulty in treatment of impacted canines. Inte rater and intra rater reproducibility and reliability of this index with 2-D measures have been analysed in this study.

Finally in this retrospective CBCT study we have analysed the extent of lateral incisor root resorption with the KPG score. One way ANOVA conducted to compare the mean KPG and lateral incisor root resorption (LIRR) showed highly statistical significance of $P<0.05$. **Table 12** showed as the mean KPG increases LIRR increased in their severity grade. This may further validate the KPG index in predicting the lateral incisor root resorption.

SUMMARY AND CONCLUSION

The present study was done at Department of Orthodontics and Dentofacial orthopedics, Tamil Nadu Government Dental College and Hospital. Patients CBCT records were retrieved from the Department of Oral Medicine and Radiology taken from January to December 2013. Total 28 patients with 42 impacted maxillary canine, age group ranging from 13 to 28 years (mean age = 18 years) of either gender were included in the study. The impacted teeth were assessed by the 3 D volumetric image and 1 mm tomographic sections in sagittal, axial and coronal planes. Cross sectional CBCT images were evaluated for labial, mid alveolus and palatal position of the impaced canine, type of impaction, root resorption of the permanent incisors. All the images were visualized by Carestream 3D software(CS3D).

The aim of the study was to assess the degree of difficulty for the treatment of impacted canines using KPG index and to analyse the lateral incisor root resorption using CBCT. This is, to determine the position of maxillary canine in 3D and analyse type of impaction, to assess the degree of difficulty for the treatment of impacted maxillary canine using KPG index, to find the reliability in assessing the KPG index by inter and intrarater agreement, to find the agreement between 2D and 3D methods in predicting treatment difficulty and to relate the severity of Lateral incisor root resorption to the score of KPG index. Digital Panaromic radiograph was created from three dimensional scans.

Firstly, the localisation of the impacted maxillary canines was done 3-dimensionally i.e., the location and distribution of impacted canines were assessed

and the orientation of the impacted canines were recorded as 6 types given by Liu et al[51] namely mesio-palatal, mesio-labial, mesio-distally insitu, distal, horizontal and inverted. In this study, out of 42 total impactions,31% were M-P-I,26% were M-L-I,26% were In situ,7% were Distal and 10% were Horizontal impactions. Inverted impactions were not reported in this study.

The novel KPG index was used to assess the treatment difficulty of maxillary impacted canines in this study. Out of 42 canines assessed,30 were with moderate score,10 were with difficult score,1 with extremely difficult and 1 with easy score. An easy impaction would require a short time of treatment and may need basic orthodontic guidance. A moderate impaction requires longer treatment times, and an impacted canine scored as difficult would require even lengthier treatment, involving more advanced orthodontic techniques. An impaction that is classified as extreme difficulty for the orthodontist could require the intervention of an oral surgeon before the canine can be brought into position, or the impacted tooth may simply need to be extracted.

On evaluating the level of agreement between observers in assessment of canine impactions using KPG index, we found almost perfect agreement in this study. Kappa statistics were done to analyse it. It showed that this index is highly reliable and further prospective studies are needed to confirm its validity in estimating accurate treatment time with differing mechanics. In doing so, this novel 3-D KPG index will become increasingly valuable to orthodontists.

Reliability of this KPG index with 2D measures of difficulty assessment of canine impaction was also carried out in our study using chi-square tests with Yates correction. It was found that statistically significant association was

present between KPG index and 2D methods and the results indicate that 3D radiological techniques, could allow us to better understand how the position of an impacted canines relates to treatment time.

The final aim of our study was to relate the severity of lateral incisor root resorption to the score of KPG index. In recent years, CBCT has been found to be a valuable tool in the detection of root resorption associated with impacted canines[12]. In this study, the occurrence and the extent of root resorption in CBCT based on the grading system given by Ericson and Kurol[48] was evaluated. Contact relationship of impacted canines with maxillary central and lateral incisors was analysed.88% of lateral incisor and 60% of central incisors had contact with maxillary impacted canines. 3-dimensional observation of root resorption was graded as no resorption, slight, moderate and severe. Out of 41 lateral incisors assessed, 13 had 'no' resorption,17 had 'slight',10 had 'moderate' and 1 had 'severe' resorption. Amongst 42 central incisors, 32 had no resorption,6 had 'slight', 2 had 'moderate' and 2 had 'severe' resorption. This showed lateral incisors were more affected than central incisors by root resorption and most of the resorptions occured where the canine was in close contact with the lateral incisors. Finally, we compared the severity of these lateral incisor root resorption and the score of KPG index by conducting one way ANOVA analysis. This showed statistically significant result and, as the mean KPG increases LIRR increased in their severity grade. By this study, we validated the difficulty score of the novel 3-D KPG index with increasing grade of lateral incisor root resorption. This may help in prediction of the lateral incisor root resorption from the difficulty score of KPG index.

BIBLIOGRAPHY

1. Maverna, R., &Gracco, A. (2006). Different diagnostic tools for the localization of impacted maxillary canines: clinical considerations. *Progress in orthodontics*, *8*(1), 28-44.
2. Léauté-Labrèze, C., de la Roque, E. D., Hubiche, T., Boralevi, F., Thambo, J. B., &Taïeb, A. (2008).Propranolol for severe hemangiomas of infancy. *New England Journal of Medicine*, *358*(24), 2649-2651.
3. Bishara, S. E. (1992). Impacted maxillary canines: a review. *American Journal of Orthodontics and DentofacialOrthopedics*, *101*(2), 159-171.
4. Bedoya, M. M., & Park, J. H. (2009).A review of the diagnosis and management of impacted maxillary canines. *Journal of the American Dental Association (1939)*, *140*(12), 1485-1493.
5. Alqerban, A., Jacobs, R., Lambrechts, P., Loozen, G., &Willems, G. (2009). Root resorption of the maxillary lateral incisor caused by impacted canine: a literature review. *Clinical oral investigations*, *13*(3), 247-255.
6. WarfordJr, J. H., Grandhi, R. K., &Tira, D. E. (2003).Prediction of maxillary canine impaction using sectors and angular measurement. *American journal of orthodontics and dentofacialorthopedics*, *124*(6), 651-655.
7. Anwar, A. Y. E. S. H. A., Jan, H., &Naureen, S. (2008). Two dimentional localization of impacted maxillary canines and their correlation. *Pakistan Oral Dent J*, *28*, 13-20.
8. Richardson, G., & Russell, K. A. (2000).A review of impacted permanent maxillary cuspids-diagnosis and prevention. *JOURNAL-CANADIAN DENTAL ASSOCIATION*, *66*(9), 497-502.

9. Walker, L., Enciso, R., &Mah, J. (2005). Three-dimensional localization of maxillary canines with cone-beam computed tomography. *American journal of orthodontics and dentofacialorthopedics*, *128*(4), 418-423.
10. Scarfe, W. C., Farman, A. G., &Sukovic, P. (2006). Clinical applications of cone-beam computed tomography in dental practice. *Journal-Canadian Dental Association*, *72*(1), 75.
11. Kau, C. H., Lee, J. J., &Souccar, N. M. (2013).The validation of a novel index assessing canine impactions. *European Journal of Dentistry*, *7*(4), 399.
12. Alqerban, A., Jacobs, R., Souza, P. C., &Willems, G. (2009). In-vitro comparison of 2 cone-beam computed tomography systems and panoramic imaging for detecting simulated canine impaction-induced external root resorption in maxillary lateral incisors. *American Journal of Orthodontics and DentofacialOrthopedics*, *136*(6), 764-e1.
13. Kau, C. H., Pan, P., Gallerano, R. L., & English, J. D. (2009).A novel 3D classification system for canine impactions—the KPG index. *The International Journal of Medical Robotics and Computer Assisted Surgery*, *5*(3), 291-296.
14. Thilander, B., &Jakobsson, S. O. (1968).Local factors in impaction of maxillary canines. *ActaOdontologica*, *26*(1-2), 145-168.
15. Ericson, S., &Kurol, J. (1986).Longitudinal study and analysis of clinical supervision of maxillary canine eruption. *Community dentistry and oral epidemiology*, *14*(3), 172-176.
16. Jacoby, H. (1983). The etiology of maxillary canine impactions. *American journal of orthodontics*, *84*(2), 125-132.

17. Jacobs, S. G. (1996). The impacted maxillary canine.Further observations on aetiology, radiographic localization, prevention/interception of impaction, and when to suspect impaction. *Australian dental journal*, *41*(5), 310-316.
18. Becker, A., Gillis, I., &Shpack, N. (1999).The etiology of palatal displacement of maxillary canines. *Clinical orthodontics and research*, *2*(2), 62-66.
19. Becker, A., &Chaushu, S. (2000). Dental age in maxillary canine ectopia.*American Journal of Orthodontics and Dentofacial Orthopedics*, *117*(6), 657-662.
20. Suri, L., Gagari, E., &Vastardis, H. (2004). Delayed tooth eruption: pathogenesis, diagnosis, and treatment. A literature review. *American journal of orthodontics and dentofacialorthopedics*, *126*(4), 432-445.
21. Sacerdoti, R., &Baccetti, T. (2004).Dentoskeletal features associated with unilateral or bilateral palatal displacement of maxillary canines. *The Angle Orthodontist*, *74*(6), 725-732.
22. Litsas, G., &Acar, A. (2011). A review of early displaced maxillary canines: etiology, diagnosis and interceptive treatment. *The open dentistry journal*, *5*, 39.
23. Ericson, S., &Kurol, J. (1987).Radiographic examination of ectopically erupting maxillary canines. *American Journal of Orthodontics and DentofacialOrthopedics*, *91*(6), 483-492.
24. Ericson, S., &Kurol, J. (1988).Early treatment of palatally erupting maxillary canines by extraction of the primary canines. *The European Journal of Orthodontics*, *10*(4), 283-295.

25. Lindauer, S. J., Rubenstein, L. K., Hang, W. M., Andersen, W. C., & Isaacson, R. J. (1992). Canine impaction identified early with panoramic radiographs.*Journal of the American Dental Association (1939), 123*(3), 91-2.
26. Power, S. M., & Short, M. B. (1993).An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. *Journal of Orthodontics*, *20*(3), 215-223.
27. Stivaros, N., &Mandall, N. A. (2000).Radiographic factors affecting the management of impacted upper permanent canines. *Journal of Orthodontics*,*27*(2), 169-173.
28. Crescini, A., Nieri, M., Buti, J., Baccetti, T., &Pini Prato, G. P. (2007). Orthodontic and periodontal outcomes of treated impacted maxillary canines: An appraisal of prognostic factors. *The Angle orthodontist*, *77*(4), 571-577.
29. Stewart, J. A., Heo, G., Glover, K. E., Williamson, P. C., Lam, E. W., & Major, P. W. (2001). Factors that relate to treatment duration for patients with palatally impacted maxillary canines. *American Journal of Orthodontics and DentofacialOrthopedics*, *119*(3), 216-225.
30. WarfordJr, J. H., Grandhi, R. K., &Tira, D. E. (2003).Prediction of maxillary canine impaction using sectors and angular measurement. *American journal of orthodontics and dentofacialorthopedics*, *124*(6), 651-655.
31. Pitt, S., Hamdan, A., & Rock, P. (2006).A treatment difficulty index for unerupted maxillary canines. *The European Journal of Orthodontics*, *28*(2), 141-144.
32. Liu, D. G., Zhang, W. L., Zhang, Z. Y., Wu, Y. T., & Ma, X. C. (2007). Three-dimensional evaluations of supernumerary teeth using cone-beam

computed tomography for 487 cases. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, *103*(3), 403-411.

33. Halazonetis, D. J. (2005). From 2-dimensional cephalograms to 3-dimensional computed tomography scans. *American journal of orthodontics and dentofacialorthopedics*, *127*(5), 627-637.
34. Sukovic, P. (2003). Cone beam computed tomography in craniofacial imaging.*Orthodontics& craniofacial research*, *6*(s1), 31-36.
35. Mah, J., & Hatcher, D. (2003). Current status and future needs in craniofacial imaging. *Orthodontics & craniofacial research*, *6*(s1), 10-16.
36. Mah, J. K., Danforth, R. A., Bumann, A., & Hatcher, D. (2003). Radiation absorbed in maxillofacial imaging with a new dental computed tomography device. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, *96*(4), 508-513.
37. Preda, L., La Fianza, A., Di Maggio, E. M., Dore, R., Schifino, M. R., Campani, R., ...&Sfondrini, M. F. (1997). The use of spiral computed tomography in the localization of impacted maxillary canines. *Dentomaxillofacial Radiology*, *26*(4), 236-241.
38. Freisfeld, M., Dahl, I. A., Jäger, A., Drescher, D., &Schüller, H. (1999). X-ray diagnosis of impacted upper canines in panoramic radiographs and computed tomographs. *Journal of OrofacialOrthopedics/Fortschritte der Kieferorthopädie*,*60*(3), 177-184.
39. Alqerban, A., Jacobs, R., Fieuws, S., &Willems, G. (2011). Comparison of two cone beam computed tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. *The European Journal of Orthodontics*, *33*(1), 93-102.

40. Botticelli, S., Verna, C., Cattaneo, P. M., Heidmann, J., &Melsen, B. (2010).Two-versus three-dimensional imaging in subjects with unerupted maxillary canines. *The European Journal of Orthodontics*, cjq102.

41. Haney, E., Gansky, S. A., Lee, J. S., Johnson, E., Maki, K., Miller, A. J., & Huang, J. C. (2010). Comparative analysis of traditional radiographs and cone-beam computed tomography volumetric images in the diagnosis and treatment planning of maxillary impacted canines. *American Journal of Orthodontics and DentofacialOrthopedics*, *137*(5), 590-597.

42. Oberoi, S., &Knueppel, S. (2012). Three-dimensional assessment of impacted canines and root resorption using cone beam computed tomography. *Oral surgery, oral medicine, oral pathology and oral radiology*, *113*(2), 260-267.

43. Wriedt, S., Jaklin, J., Al-Nawas, B., &Wehrbein, H. (2012).Impacted upper canines: examination and treatment proposal based on 3D versus 2D diagnosis. *Journal of OrofacialOrthopedics/Fortschritte der Kieferorthopädie*, *73*(1), 28-40.

44. San Martín, D. E., English, J. D., Kau, C. H., Gallerano, R. L., McGrory, K. R., Salas, A. M., ... & Xia, J. J. (2012). The KPG index--a novel 3D classification system for maxillary canine impactions. *Texas dental journal*, *129*(3), 265-274.

45. Dalessandri, D., Migliorati, M., Rubiano, R., Visconti, L., Contardo, L., Di Lenarda, R., & Martin, C. (2013). Reliability of a Novel CBCT-Based 3D Classification System for Maxillary Canine Impactions in Orthodontics: The KPG Index. *The Scientific World Journal*, *2013*. V

46. Kau, C. H., Lee, J. J., &Souccar, N. M. (2013).The validation of a novel index assessing canine impactions. *European Journal of Dentistry*, *7*(4), 399.

47. Dalessandri, D., Migliorati, M., Visconti, L., Contardo, L., Kau, C. H., & Martin, C. (2014). KPG Index versus OPG Measurements: A Comparison between 3D and 2D Methods in Predicting Treatment Duration and Difficulty Level for Patients with Impacted Maxillary Canines. *BioMed research international*, *2014*.
48. Ericson, Sune, and JüriKurol. "Resorption of incisors after ectopic eruption of maxillary canines: a CT study." *The Angle orthodontist* 70.6 (2000): 415-423.
49. Ericson, S., &Kurol, J. (2000). Incisor root resorptions due to ectopic maxillary canines imaged by computerized tomography: a comparative study in extracted teeth. *The Angle orthodontist*, *70*(4), 276-283.
50. Ericson, S., Bjerklin, K., &Falahat, B. (2002). Does the canine dental follicle cause resorption of permanent incisor roots? A computed tomographic study of erupting maxillary canines. *The Angle orthodontist*, *72*(2), 95-104.
51. Liu, D. G., Zhang, W. L., Zhang, Z. Y., Wu, Y. T., & Ma, X. C. (2008). Localization of impacted maxillary canines and observation of adjacent incisor resorption with cone-beam computed tomography. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, *105*(1), 91-98.
52. Cernochova, P., Krupa, P., &Izakovicova-Holla, L. (2011). Root resorption associated with ectopically erupting maxillary permanent canines: a computed tomography study. *The European Journal of Orthodontics*, *33*(5), 483-491.
53. Mead, S. V. (1954). Oral Surgery, St. *Louis, The C. V. Mosby Co*.
54. Rossini, G., Cavallini, C., Cassetta, M., Galluccio, G., &Barbato, E. (2012). Localization of impacted maxillary canines using cone beam computed tomography. Review of the literature. *Annali di stomatologia*, *3*(1), 14.

55. Novak, P. D., Jefferson Keith, M. A., Anderson, D. M., & Elliot, M. A. (2004). Dorland's illustrated medical dictionary.

56. Nagpal, A., Pai, K. M., Setty, S., & Sharma, G. (2009). Localization of impacted maxillary canines using panoramic radiography. *Journal of oral science*, *51*(1), 37.

57. Guerrero, M. E., Shahbazian, M., ElsienaBekkering, G., Nackaerts, O., Jacobs, R., & Horner, K. (2011). The diagnostic efficacy of cone beam CT for impacted teeth and associated features: a systematic review. *Journal of oral rehabilitation*, *38*(3), 208-216.

58. Syryńska, M. A. R. I. A., &Budzyńska, A. G. A. T. A. (2007, December). [The incidence of uni-and bilateral impacted maxillary canines and their position in dental arch depending on gender and age]. In *Annales AcademiaeMedicaeStetinensis* (Vol. 54, No. 2, pp. 132-137).

59. Dachi, S. F., & Howell, F. V. (1961). A survey of 3,874 routine full-mouth radiographs: I. A study of retained roots and teeth. *Oral Surgery, Oral Medicine, Oral Pathology*, *14*(8), 916-924.

60. SCHINDEL, R. H., & SHEINIS, M. R. (2013). Prediction of maxillary lateral-incisor root resorption using sector analysis of potentially impacted canines.*Journal of clinical orthodontics: JCO*, *47*(8), 490-493.

ASSESSMENT OF DIFFICULTY

Patient	SIDE	TYPE	3-D KPG INDEX							2-D MEASURES	
			X-AXIS		Y-AXIS		Z-AXIS		KPG SCORE	STEWART (mm)	ERICSON & KUROL(Sector)
			C.T	R.T	C.T	R.T	C.T	R.T			
1	R	MB	3	4	3	0	2	4	16	16.7	3
	L	MB	4	5	3	0	2	2	16	15.1	4
2	L	MP	5	4	3	0	3	2	17	14.8	5
3	R	MP	5	2	2	1	2	2	14	14.5	5
	L	MP	4	2	2	0	1	1	10	7.1	4
4	R	MP	3	3	3	0	2	2	13	9.2	3
	L	MP	3	4	3	0	2	2	14	11.9	3
5	R	Insitu	1	3	2	1	2	5	14	11	1
	L	Distal	5	1	3	0	3	2	14	11.5	5
6	R	MB	5	0	3	0	2	2	12	10.6	5
7	R	MP	4	3	2	0	2	1	12	10.5	4
8	R	MP	2	3	2	0	2	2	11	8	2
	L	MP	4	3	3	0	2	2	14	13	4
9	L	Horizontal	5	5	4	0	3	3	20	18.1	5
10	R	Insitu	1	2	2	0	2	3	10	8.4	1
	L	Insitu	1	2	2	0	1	2	8	7.7	1
11	R	MP	4	3	3	0	2	1	13	13.5	4
	L	MP	4	3	3	0	1	2	13	13.4	4
12	R	Insitu	2	3	2	0	2	2	11	10.8	2
	L	Insitu	1	4	3	0	2	3	13	12.8	1
13	R	Insitu	1	4	3	0	2	1	11	12.7	1
	L	Insitu	1	3	2	0	4	2	12	9.9	1
14	R	Insitu	0	1	1	0	2	2	6	3.7	1
	L	Insitu	2	3	3	0	0	0	8	9.7	2
15	L	Horizontal	4	4	4	0	3	2	17	17.9	4
16	L	MP	5	1	3	1	3	4	17	11.2	5

17	R	MP	4	2	2	0	2	3	13	14.9	4
18	L	MP	3	4	4	0	1	0	12	14.9	3
19	R	MB	3	4	3	0	1	1	12	15.4	3
	L	MP	4	4	2	0	3	2	15	9.3	4
20	R	MP	5	3	3	0	3	2	16	13.8	5
21	R	Distal	3	3	1	0	1	0	8	0	3
	L	Insitu	0	4	3	0	0	4	11	10.3	1
22	R	Distal	2	4	2	0	1	3	12	10.3	2
23	R	Horizontal	4	4	4	0	3	4	19	15.8	4
24	L	MB	3	3	3	0	0	3	12	10.7	3
25	L	MP	3	3	2	0	3	1	12	9.7	3
26	R	MB	4	4	3	0	2	2	15	18.1	4
	L	MB	4	4	3	0	2	4	17	19.3	4
27	L	MP	5	4	2	0	2	0	13	12.3	5
28	R	Horizontal	5	3	3	0	1	0	12	16.9	5
	L	Insitu	3	2	2	1	3	0	11	7.4	3

C.T - CUSP TIP

R.T - ROOT TIP

MB - MESIO BUCCAL

MP - MESIOPLALTAL

R - RIGHT

L - LEFT

INTER AND INTRA RATER RELIABILITY

NO.	SIDE	Observer 1		Observer 2		Observer 3		Observer 1		Observer 2		Observer 3	
		T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	R	16	16	15	17	16	17	D	D	D	D	D	D
	L	16	16	15	17	15	17	D	D	D	D	D	D
2	L	17	18	19	18	18	18	D	D	D	D	D	D
3	R	14	14	14	13	14	14	MOD	MOD	MOD	MOD	MOD	MOD
	L	10	11	12	12	9	12	MOD	MOD	MOD	MOD	MOD	MOD
4	R	13	14	14	14	12	14	MOD	MOD	MOD	MOD	MOD	MOD
	L	14	14	14	15	15	15	MOD	MOD	MOD	D	D	D
5	R	14	13	13	13	13	13	MOD	MOD	MOD	MOD	MOD	MOD
	L	14	14	14	14	14	14	MOD	MOD	MOD	MOD	MOD	MOD
6	R	12	12	12	14	12	14	MOD	MOD	MOD	MOD	MOD	MOD
7	R	12	13	13	14	12	14	MOD	MOD	MOD	MOD	MOD	MOD
8	R	11	11	13	12	11	13	MOD	MOD	MOD	MOD	MOD	MOD
	L	14	14	16	16	14	15	MOD	MOD	D	D	MOD	D
9	L	20	20	18	18	18	15	EXT	EXT	D	D	D	D
10	R	10	10	12	12	7	7	MOD	MOD	MOD	MOD	MOD	MOD
	L	8	8	8	8	10	10	MOD	MOD	MOD	MOD	MOD	MOD
11	R	13	13	11	13	13	13	MOD	MOD	MOD	MOD	MOD	MOD
	L	13	13	9	10	13	11	MOD	MOD	MOD	MOD	MOD	MOD
12	R	11	11	12	11	12	12	MOD	MOD	MOD	MOD	MOD	MOD
	L	13	13	14	13	12	13	MOD	MOD	MOD	MOD	MOD	MOD
13	R	11	11	11	12	11	12	MOD	MOD	MOD	MOD	MOD	MOD
	L	12	12	11	13	12	13	MOD	MOD	MOD	MOD	MOD	MOD
14	R	6	6	6	6	6	6	E	E	E	E	E	E
	L	8	8	9	9	9	10	MOD	MOD	MOD	MOD	MOD	MOD
15	L	17	17	16	18	17	17	D	D	D	D	D	D

16	L	17	17	17	15	15	16	D	D	D	D	D	D
17	R	13	13	15	14	15	15	MOD	MOD	D	MOD	D	D
18	L	12	12	11	13	12	14	MOD	MOD	MOD	MOD	MOD	MOD
19	R	12	12	13	14	13	11	MOD	MOD	MOD	MOD	MOD	MOD
	L	15	15	15	14	16	16	D	D	D	MOD	D	D
20	R	16	16	18	17	18	18	D	D	D	D	D	D
21	R	11	12	13	11	9	9	MOD	MOD	MOD	MOD	MOD	MOD
	L	8	8	11	7	9	10	MOD	MOD	MOD	MOD	MOD	MOD
22	R	12	12	12	13	13	14	MOD	MOD	MOD	MOD	MOD	MOD
23	R	19	19	18	18	20	18	D	D	D	D	EXT	D
24	L	12	12	8	9	12	9	MOD	MOD	MOD	MOD	MOD	MOD
25	L	12	12	12	14	12	14	MOD	MOD	MOD	MOD	MOD	MOD
26	R	15	15	15	17	15	16	D	D	D	D	D	D
	L	17	17	18	18	18	16	D	D	D	D	D	D
27	L	13	14	14	14	14	13	MOD	MOD	MOD	MOD	MOD	MOD
28	R	12	12	12	14	12	13	MOD	MOD	MOD	MOD	MOD	MOD
	L	11	11	11	12	12	12	MOD	MOD	MOD	MOD	MOD	MOD

E - EASY

MOD - MODERATE

D -DIFFICULT

EXT - EXTREMELY DIFFICULT